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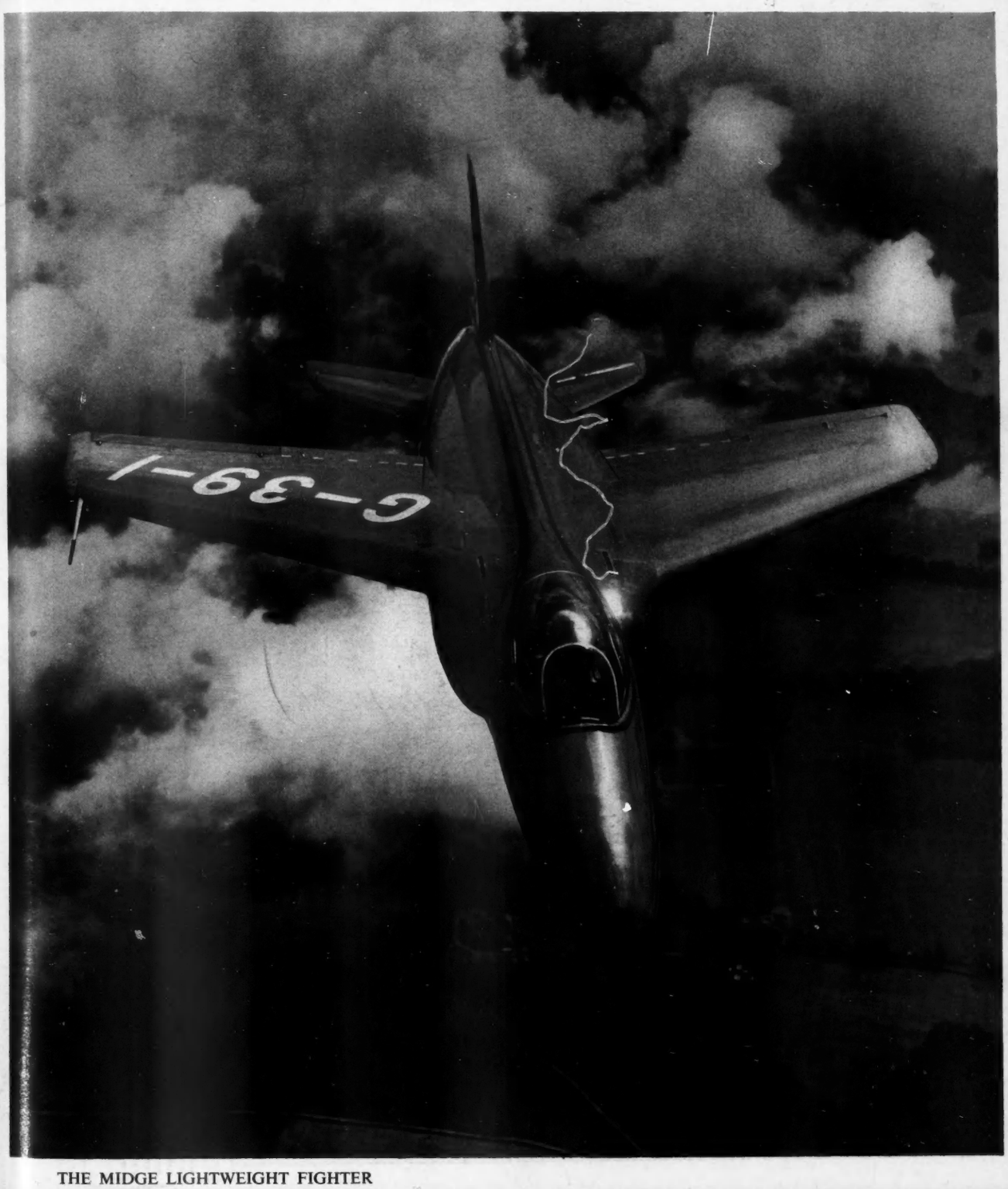

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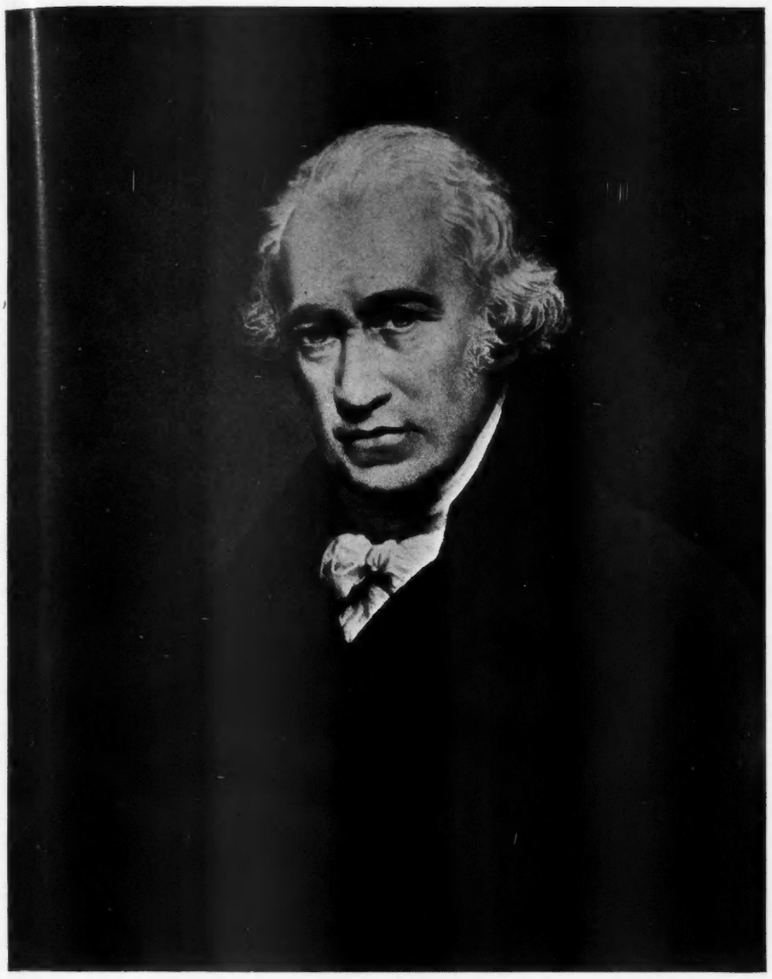

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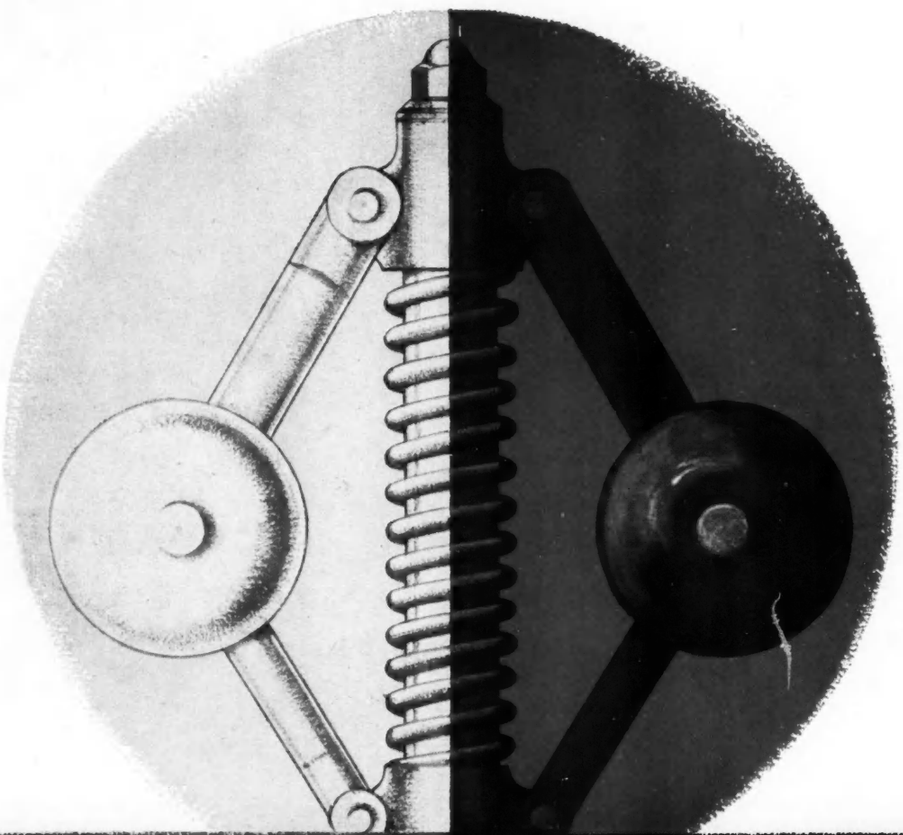

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A SENSE OF VALUES

It is surprising how frequently a changing tide of opinion is revealed almost simultaneously by a number of speakers and writers. A similar phenomenon has often been noted in the development of science : several workers take the same step forward at about the same time although they are unaware of each other's activities. But whereas in the scientific field a new discovery is to-day quickly recognised (if, indeed, it has not already been forecast), a new opinion, a new sense of proportion in fundamental issues, or a new recognition of some vital principle, spreads slowly.

Such a moment seems to have arrived in Britain. A steadily rising standard of living is a conception which has been sacrosanct for a good many years. It has served as a powerful weapon in the armoury of politicians. It has been the justification of scientists and engineers, excusing them, very often, from some of the less pleasant consequences of their work. No one has thought, of doubting its desirability. But now, at several points, doubts are cast. At the annual dinner of the Institution of Mechanical Engineers (reported on another page), Lord Chandos—with perfect grace—charged engineers with having caused " the artificial economy under which we live." " No one," he said, " would be the worse for paying a little more attention to the humanities and a little less to equations." At least one of his hearers wished for more in this vein, because the chairman of a large engineering group, who has served his country as Secretary of State for the Colonies during three difficult years, could undoubtedly enlighten us on technology and technological education in relation to the problem of raising the standard of living of those nations which are industrially undeveloped. Instead he chose—appropriately for the occasion of his speech—to drop a few hints: " I think there is a tendency in the modern world to imagine that technical education is the be-all and end-all of human effort. I am not sure that that is a very good idea."

On another day last week, at a smaller gathering, much the same idea was expressed. It was at one of those informal luncheons of the Old Centralians (the Old Students' Association of the City and Guilds Engineering College) where the meeting of friends is enlivened by a short address from a guest speaker. Mr. J. S. Fulton, who is Principal of University College, Swansea, and Vice-Chancellor of the University of Wales, spoke on " The Challenge of African Education." From the experience of an official visit to Sierra Leone to consider plans for education there, he drew the conclusion that Britain must make a great effort to help such countries to establish better educational facilities, so that they can gradually raise their standard of living and cultivate democratic government. Although he is himself a product of the humanities rather than the sciences, he insisted that the sciences provided an admirable educational discipline. An audience of engineers, it might be thought, would have been delighted with such an opinion from such an authority. But when an informal discussion started, one of the speakers, an engineer, pleaded for less concentration on technology and more on the humanities. It was odd, after hearing such a gallant defence of science from Mr. Fulton, to hear an engineer spurn it.

Doubt was cast for the third time when Mr. George Schwartz, writing in the *Sunday Times*, poked fun at the Chancellor's recent statement that we in this country could double our standard of living in the next quarter of a century. He did not question our ability to do this; he simply remarked that people would still be able to point to others more wealthy than themselves. The standard of living would rise but the familiar relative scale of personal wealth would persist. It is this scale which largely determines the individual's sense of prosperity.

These three instances have the appearance of a reaction from too much talk and boasting of science and technology and the standard of living. Other signs can be found of a reaction of this kind in Britain. If it is true, then, that the tide of opinion is turning in this way, what are the causes and the probable consequences? The chief cause is almost certainly the fact that we in this country have had to accept the disagreeable fact that we are no longer the most powerful industrial nation. We derive some compensation by asking whether, after all, a high standard of living is the only thing in life which matters. It is unlikely that the reaction will go so far as to affect our industrial productivity—social forces are too strong for that—but it will certainly lead to a new sense of proportion. That will be a significant gain. It will restore to us the moral lead of the world which we have never wholly lost. And the moral lead will, perhaps, count for more in the future than the industrial lead, especially among the peoples of the undeveloped countries. As Mr. Fulton insisted, there is noble work waiting to be done in those countries—work which can be done best by scientists and engineers, teachers and practitioners, who have cultivated a mature sense of values.

Weekly Survey

YEAR'S STEEL TARGET IN SIGHT

User industries, engineering prominent among them, continue to keep the steel industry operating at full capacity. Indeed, so great has been the surge in demand for sheet from the motor-vehicle industry, tinplate from the canning industry, rolled steel from the building industry and rods from certain sections of the export market, that a serious shortage could well develop in the near future. In the first nine months of this year steel ingot production was 13,740,400 tons compared with 13,041,800 tons in the same period of 1953. This has been achieved in spite of interruptions due to a strike in South Wales and certain mechanical difficulties on the North East Coast. There is thus every prospect that the target of 18½ million tons set for 1954 will be achieved—which would be about 900,000 tons above the record level established last year.

Supplies of finished steel have had to be imported recently in the case of sheet to keep pace with the expansion of the motor-vehicle industry, although there was an increase of 16 per cent. in sheet production in the first six months of this year. Total imports of sheet steel this year are in fact expected to be about 200,000 tons, most of it coming from North America. There is some indication, however, that a substantial recovery is developing in the United States steel industry and supplies may not be easy to obtain from this source in the closing weeks of the year. Demand for tinplate in the first half of the year increased by 24 per cent. over the same period of 1953 and trade associations in the food manufacturing industries have found it necessary to approach the Ministry of Food this week to discuss what they consider to be the inadequate allocation of tinplate to the food canning industry in the fourth quarter of this year. It would take a sudden reversal in the principal industries using steel to prevent the industry achieving a record steel output in 1954. Such a sudden reversal in fortune is not impossible, for the imposition of quotas in Australia—to take one example—can quickly and seriously affect the outlook for the motor-car industry. But such an eventuality is possible rather than probable.

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POWER STATION VARIATIONS

Superficially, modern power stations tend more and more to conform to a "sealed pattern," although certain interesting points of difference between them can generally be picked out by the pertinacious observer. For instance, the difficulty of finding suitable sites on estuaries has been overcome at the 330-MW station at Brunswick Wharf in the east of London (which was formally opened by Lord Citrine on Wednesday, October 6) by building it in a disused dock on Thameside. It is true that this is not a unique expedient, since the same practice was adopted at Clarence Dock, Liverpool, years ago. It has, however, both technical and economic advantages as it ensures ample water supplies and good facilities for coal storage.

Another interesting feature of Brunswick Wharf (which is described in this issue) is the adoption of indoor switchgear on the 132-kV circuits. At first sight this may seem a retrograde step, but when it is remembered that the low-level switching stations which are a familiar feature of the national grid require a floor area of over 6,000 sq. ft. per circuit and that land, particularly near large cities, is hard to come by, opinion may be revised. For indoor switchgear, apart from requiring a space of only 1,400 sq. ft. per circuit, has the added advantages that frequent cleaning of the insulators—so essential in areas where the air is heavily polluted—is unnecessary; and that maintenance can be carried out, at least at Brunswick Wharf, in an air-conditioned atmosphere. It is understood that the first cost, including that of the buildings, does not greatly exceed that of outdoor equipment and that any excess is offset by its advantages.

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ELECTRONICS IN SCOTLAND

For some time the Scottish Council have been anxious to develop the electronic industry in Scotland, and with the help of the Ministry of Supply and of the Admiralty a scheme was devised to establish a central source from which parts of large-scale development projects could be sub-contracted to smaller teams. The function of the central establishment would extend to the provision of guidance and training in electronics so that other concerns could become capable of carrying out the work. The works of Ferranti, Limited, at Edinburgh, were finally chosen as the central establishment and there engineers from other firms would be trained.

The Ministry of Supply, therefore, sponsored the building of a new laboratory block (the opening of which by H.R.H. The Duke of Edinburgh is recorded elsewhere in this issue) which would afford suitable premises not only for Ferranti's own research work, but also for the training of engineers from other firms, up to about 40 at any one time. Technical advice and "know how" will also be available as regards staff selection and contract problems in connection with Government development work. The scheme has already been operating on a restricted scale and some firms have proceeded to the stage of independent design and production of commercial electronic apparatus. The opening of the new laboratories will enable the process to be widened and it is hoped that it will enable the electronic industry to become well established in Scotland.

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WORLD BANK LOANS FOR MAJOR WORKS

In the nine years of its existence the International Bank for Reconstruction and Development, whose annual report has recently been published, has made 104 loans, and is committed to a total of just under two million dollars in 34 countries. A high proportion of this amount has been advanced for basic engineering works: 27 per cent. for electric power, 21 per cent. for transport, 1·4 per cent. for telecommunication equipment. Irrigation and flood control accounted for 3 per cent., farm and timber machinery for 4·4 per cent. and plant for mining and manufacturing industry for 9 per cent.

Current and future projects follow the same pattern. During the year under review, out of a total of 324 million dols. the sum of 119 million dols. was lent for transport, including railway improvements in Brazil, French West Africa and South Africa. Road construction was financed in Columbia, Ecuador and Nicaragua. Norway received a loan for the purchase of new merchant ships and Turkey for a port development programme. Loans to the value of 107 million dols. were made for expansion of electrical generating and distributing facilities, chiefly to Japan, South Africa and Brazil. A number of new projects are mentioned for which negotiations have recently been concluded or which are still under discussion. These include two electric power plants in Bombay, one thermal and the other hydro-electric. A further loan is to be made to help finance the next stage of the Aberdeen-Laksapana hydro-electric scheme in Ceylon. A storage dam is to be built on the Kehalganu and 25 MW added to the generating capacity of the station. Additional transmission lines will also be constructed.

In Egypt the Bank is to review a project for a high dam on the Nile above Aswan to provide flood control, irrigation and hydro-electric power; and also a proposal for the manufacture of fertiliser by using the generating capacity now being installed at the existing Aswan dam. In Pakistan, projects have been discussed to expand the capacity of the Karachi Electric Supply Corporation; to rehabilitate wharves at the port of Karachi; for the further development of railways and for a pulp and paper mill in East Pakistan. The Bank is collaborating with the Mexican Government in a comprehensive study of Mexico's future requirements of electric power and is studying a project for the rehabilitation of the Pacific railroad. In Peru the Bank is starting negotiations for a loan for the construction of a cement plant in the north. In Uruguay discussions are well advanced on the proposed financing of a new 50-MW thermal power unit in Montevideo and on the construction of a 103-MW hydro-electric plant on the Rio Negro.

The total amount involved is small compared with the total of world trade and investment, but the effect of some of these projects on the economies of the countries concerned, and in particular on their markets for industrial products, can be quite substantial.

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MACHINE TOOLS FOR HIRE

One of the oldest American machine tool companies, Jones and Lamson Machine Co., of Vermont, recently announced a scheme to hire out their products, with or without option to buy, and another for hire-purchase. The customer is given the choice between these two schemes and outright purchase for cash. The idea of hiring machine tools, with a clause in the contract leaving the customer free to buy when he chooses, is not new to the United States industry. The Kearney and Trecker Corporation of Milwaukee operate such a scheme which they advertised heavily earlier this year. Kearney and Trecker gave their customers the choice of three plans, all three catering for the hire-purchase of the machines in seven years, with options to buy at the end of the third, the second or the first year of the hire period with variations in initial rental payments. If the option to purchase is not exercised and the full period of seven years allowed to run, the total cost of the scheme to the customer amounts to 15 per cent. of the list price of the machine, whatever scheme is adopted. Later in the year the Warner and Swasey Company, who make textile machines and instruments as well as machine tools, instituted a similar plan though different in detail. Several other companies, including the Cincinnati Milling Machine Company and Monarch Machine Tool Company, operate hire-purchase plans.

The machine tool industry as a whole is not enthusiastic about these developments and considers that the volume of machines sold thus is unlikely to exceed 10 per cent. of turnover. The question of taxation—whether or not rental payments can be charged as an expense deductible for tax purposes—has not been clarified by the United States Treasury, although a decision

cannot be postponed much longer. There are also difficulties about the hire-purchase of special machines the usefulness of which may not extend to the full period of the plans.

Jones and Lamson consider that hire-purchase payments will not in fact be allowed as an expense for tax purposes and offer what they call " a true lease " plan which does not contain any option to buy, although the user of the machine may at any time tear up the contract and negotiate the purchase of the machine as a used machine. In this way Jones and Lamson consider that customers could charge rental payments as an expense, and benefit from tax concessions.

The established practice in the United Kingdom is for the hire-purchase of machine tools to be conducted through hire-purchase finance companies, such as the British Wagons Co., Ltd., Mercantile Credit Co., Ltd., Mutual Finance, Ltd., Scottish Midland Guarantee Corporation and United Dominions Trust, Ltd. The British Machine Tool Trades Association know of no manufacturer who finances his own hire-purchase sales, and if this is done it is certainly on a very small scale indeed.

The United States machine tool manufacturers' experiments are worth watching, though success or failure will not be evident for some time. One of the results may be that companies hard-pressed for cash in periods of intense competition could acquire new machines to increase their competitive ability without having to bear the full cost initially. It is hard to assess the advantages the machine tool manufacturer derives from financing his own hire-purchase schemes, except that he remains in close touch with his customer throughout the period and is able to offer a very flexible scheme tailor-made to the requirements of machine-tool users.

* * *

A BRITISH TITANIUM PLANT

Imperial Chemical Industries held a conference last week " to discuss the properties of titanium and its alloys, the problems of handling and joining the material and questions of its availability," as reported elsewhere in this issue. I.C.I. say that they have investigated several processes, including the reduction of titanium tetrachloride by magnesium and by sodium, electrolysis of various salts and direct reduction of oxides, and have decided that the sodium process is " the most promising process, especially for British conditions and that it is likely to give good quality material at a price competitive with that of any other known process." The new factory, expected to be in operation within six months, will have a capacity of 1,500 tons per annum.

At one time there were doubts in the using industries concerning the suitability of metal produced by the sodium process, particularly because of the difficulty of controlling the hardness of the ingots. I.C.I. draw attention to the fact that hardness " is probably the most difficult property to control " but assert that " it compares favourably with the product by the Kroll process, and meets the exacting needs of users." The Electro-Metallurgical Company, a Division of Union Carbide and Carbon Corporation, have also decided on the sodium process after prolonged experimental production on a pilot and prototype-plant scale at its Metals Research Laboratories in Niagara Falls, New York. A plant with an annual output of 7,500 tons (costing approximately 31½ million dols.) is being erected in Ashtabula, Ohio, and is scheduled to come into production in about a year and a half.

There is, however, no unanimity in the choice of methods by leading producers. An electrolytic process was developed by Horizons Inc., Cleveland, which will be used by Singmaster and Breyer in a new titanium plant to be built in Stamford, Connecticut. This process, it is claimed, will lead to a considerable reduction in production costs, but little is yet known of its suitability for the production of very pure metal on a large scale (purity is essential, otherwise the metal cannot be worked). Another, Canadian, company—Shawinigan Water and Power Corporation—are using the electrolytic process at a semi-production plant at Shawinigan Falls, Quebec, which is expected to start production this month. Shawinigan, like Horizons, hope the electrolytic process will permit a sizeable reduction in the price of titanium.

* * *

THE CYCLE INDUSTRY

Raleigh Industries announced last week that a new 1½-acre factory is to be erected immediately and that another major factory is being planned " to meet growing home and export demands." This is being done at a time when cycle output is running at a level substantially below that of the peak post-war years, and against a background of uncertainty concerning exports to the United States, which accounted, in the first half of this year, for nearly one-fifth of total exports and for approximately 10 per cent. of total production. The industry as a whole has doubled its capacity since the war, reaching a peak production of over 4 million cycles in 1951; the level fell to 3 million in 1953 but recovered to nearly 3½ million in the 12 months ending last June. Monthly production statistics suggest that this level is being raised steadily.

There is little doubt that Raleigh have considerably strengthened their position within the industry in recent years. Their chairman, Sir Harold Bowden, has said that the company's output increased during 1953 whereas the industry's total production fell, and that Raleigh produce substantially more than a million cycles a year. This suggests that they account for at least one-third of the industry as a whole, and there is no lack of confidence in the future. Demand on the home market is very high, as is demand for all consumer durable goods. In common with those products, cycle sales received a powerful stimulant when hire-purchase regulations were eased earlier this year, as only about one-quarter of home sales are for cash. Exports are being maintained at about the same level as last year, although the imposition of a higher duty on exports to the United States (over twice those to any other market) is a real threat. Little has been said recently concerning Japanese competition, though this is obviously an important factor as the bulk of the industry's exports are to Africa and the Far East, particularly Nigeria, the Rhodesias, India, Malaya, Thailand and Indonesia.

* * *

SALES TO THE SOVIET BLOC

A wide range of goods have now been freed for export to Soviet Bloc countries and a comprehensive list has been published by the Board of Trade. For the first time lists are also published of the items still under the security embargo of the Western nations represented on the Co-ordinating Committee on East-West Trade. The general effect of the revised controls is to reduce the embargo list by about 80 items, and the list of items subject to quantitative controls by about 70 items. There remains an impressive number of engineering products on the embargo list: Diesel engines over 1,500 brake horse-power and of speeds exceeding 600 r.p.m., generators of 10,000 kW and over, motors of 12,500 brake horse-power and over and all control gear for this type of machinery, a wide range of heavy or special machine tools, machinery containing corrosive-resistant materials in excess of specified limits, and key equipment, instruments and machines needed to produce turbine blades, aircraft components, atomic energy plants, etc. Any orders booked or inquiries received for items on the embargo list will have to be submitted to the Board of Trade for approval. Controls have been relaxed, however, on a considerable number of engineering products, including general-purpose machine tools, locomotives and railway equipment (except certain types of turbine locomotives) and chemical plant.

The decision on ships has not yet been reached, and will be awaited with considerable interest by the shipbuilding industry. The Soviet Union is known to be eager to modernise her mercantile fleet and has already booked most of the shipbuilding capacity of countries within the Soviet bloc. Orders accepted by British companies so far are limited to 20 trawlers and three 10,000-ton vessels already completed. So far this year, Soviet trade agreements with West European countries include orders for at least 100 seagoing ships. In the circumstances, it is most unlikely that an embargo will be enforced, at any rate on ships up to 10,000 tons. The official freeing of ship exports might well result in large orders for British yards, particularly those that rely mainly on small cargo ships. These are just the firms to whom fresh orders would be welcome.

* * *

RAILWAY IMPROVEMENTS

Although in 1953 the British Transport Commission spent £68 million on vehicles, plant, land, etc., only a small part may be fairly described as development; for the most part this expenditure has merely been directed to the replacement of existing assets. Eight years after the end of the war the Commission still ascribe their difficulties to shortages of material and past restrictions. In respect of the railways, the sixth annual report of the Commission still bemoans the arrears of maintenance due to the war that have " hardly yet been made good." An account of some of the engineering work referred to in the report is given elsewhere in this issue.

For the future, the steps which the Commission " contemplate to gain their objectives " include " a long-term plan for the modernisation of the equipment of British Railways." No details are given, however, though the Commission are now committed to a greater use of Diesel multiple-unit trains. The overall increase in the speed of freight traffic (and, therefore, of passenger traffic also) is dependent on the substitution of a more rigid coupling and continuous power brakes for the existing loose couplings and hand brakes. The problem had, indeed, been sufficiently far examined by 1950 for an estimate to have been made of the cost of making the change, namely, £35 million. But experiments are still continuing. For an expenditure of about half what the Ford Motor Company are able to raise and spend on their expansion plans, the Commission could modernise freight traffic, so resolving many of their difficulties and enabling them to offer a much improved service to both industry and the public. For a sum probably not much more than the cost of unofficial strikes a major improvement of far-reaching value could be achieved.

THE I.MECH.E. SESSION

Annual Dinner and Presidential Address

The 1954-55 session of the Institution of Mechanical Engineers opened in traditional manner last week, with the annual dinner on Thursday and the Presidential Address on Friday.

The principal guests at the dinner, which was held at the Dorchester Hotel, London, were Viscount Chandos (formerly the Rt. Hon. Oliver Lyttelton, Colonial Secretary, and now chairman of Associated Electrical Industries, Limited) and General Sir Brian Robertson, chairman of the British Transport Commission. The chair was taken by the President, Dr. R. W. Bailey, F.R.S. Proposing the toast of the Institution, Lord Chandos devoted the first half of his speech to good-natured banter (of himself as well as his hosts), which ensured for him undivided attention to his more serious observations in the second half. Referring to the difference between the 15 or 20 million people that we could support from our resources in this island and the 50 million that we do support, he said it was made possible very largely by engineers: it was done by their technique of buying the raw materials and working them up into the wonderful machines which were the blessing and the bane of mankind. It was they who caused the artificial economy under which we lived, but it was sometimes necessary to look away from the equations and to look at the larger picture of human life and to pay a little attention to the great influences which were working upon our civilisation. "I think we all should turn sometimes from our daily task to the stored-up treasures which our ancestors left to us in English literature and poetry."

Dr. Bailey, replying to the toast, referred to technological education in the Colonies, particularly in relation to the advice and support which the three major institutions have given to the Government.

R.E.M.E.

Sir Brian Robertson replied to the toast of "Our Guests," which was proposed by Mr. P. L. Jones, vice-president. As Colonel Commandant of the Corps of Royal Electrical and Mechanical Engineers, and as a result of such inspections and visits as he had been able to make to the Corps, he could say that he had found it in a high state of efficiency and enthusiasm. He hoped that when National Service men returned to engineering firms they would be found to have gained in knowledge and character.

Before the delivery of the Presidential Address (reported on this page) at the meeting on Friday, October 15, it was announced that the Council had accepted the resignations of Mr. A. K. Lloyd, vice-president, and Mr. R. A. Riddles from the Council, and had appointed Mr. Gilbert Varley (member of Council) a vice-president, and Mr. R. C. Bond and Mr. S. J. Harley as members of Council.

Sir Richard Southwell, F.R.S., and Dr. H. J. Gough, F.R.S., past President, who have recently been elected Honorary Members of the Institution, were then welcomed formally by the President, who handed each a certificate of honorary membership. They signed the Honorary Members' book. Each was "presented" to the meeting—Sir David Pye, F.R.S., reading a citation of Sir Richard's career and distinctions, and Dr. S. F. Dorey, F.R.S., doing likewise for Dr. Gough.

The vote of thanks to Dr. Bailey for his Presidential Address was proposed by Mr. T. A. Crowe, vice-president, and seconded by Mr. Gilbert Varley.

RESEARCH IN MECHANICAL ENGINEERING

Dr. R. W. Bailey's Presidential Address

In his Presidential Address to the Institution of Mechanical Engineers on Friday, October 15, Dr. R. W. Bailey, Wh.Sc., F.R.S., said that research was not a new factor that had entered the industrial field, but was very old in the best engineering practice and had been pursued by the more competent engineers and progressive engineering concerns from early pioneering days. Engineering problems generally involved so many factors that frequently it was more profitable to know what the factors were and to assess their relative significance than to incur serious delay in striving for unessential refinement in dealing with any one factor. This often required the exercise of judgment based upon engineering considerations and pointed to the importance of training the staff in the principles of mechanical engineering sciences and knowledge, including design and workshop processes. The metallurgical knowledge of young engineers was much less than it should be.

It was fortunate that the practice of engineering was adapted to the development of staff suitable for a mechanical engineering research organisation. The fundamental matter of policy in regard to a firm's interest in research was whether to use the individual effort of the firm (which he called Principle 1); or use external aid, e.g., a research association (which he called Principle 2); or a combination of both. Comparing the advantages and disadvantages of these methods, under the headings of direction, experimental resources, staff, contact with engineering needs, and utilisation of results in development, he concluded that substantial advantages would normally accrue to a large technically-active and progressive firm conducting its research on Principle 1. There might be no case for Principle 2, except as an auxiliary to 1, when it could provide a valuable service. The natural case for Principle 2 would be that of the smaller firm and firms possessing smaller technical resources. Its several handicaps compared with Principle 1 could be important, but measures could be taken to lessen their significance.

Whatever policy characterised a firm's interest in research, the most important factor was the technical quality and capability of the staff employed. Nothing should be sacrified to that. Moderate accommodation and the right man and staff would be more successful, profitable and less costly than imposing buildings, lavish equipment, and a staff lacking in essential knowledge, understanding, energy and imagination. It was not sufficient, if Principle 2 were adopted, to subscribe to the research association and be at the receiving end to obtain the benefits of research. A closer association of user and those responsible for carrying out the research could hardly fail to increase interest on both sides and help to develop recognition by the user of the fact that he had an important part to play as partner.

Dr. Bailey concluded with a brief review of the encouragement the Institution had given to research in the past, mentioning particularly the work on lubricated journal bearings, alloys, marine oil engines and steam pipe flanges. He remarked that after the work on steam pipe flanges the Institution's direct activities in negotiating and sponsoring mechanical engineering research virtually ceased, leaving its place to be taken by the organisation or participation in symposia of international character. "The questions may well be asked," he said, "whether the present situation is wholly satisfactory from the Institution's standpoint. Whether, in fact, the collective professional knowledge and experience of its members could be used more effectively."

THE GAS INDUSTRY

Aim of Reduced Dependance on Coal

During the five years that have elapsed since the nationalisation of the gas industry, into 12 separate area gas boards directly responsible to the Minister of Fuel and Power for the manufacture, transmission, distribution and sales of gas, with a central advisory Gas Council, the costs of materials, particularly coal, have been rising, supplies of steel and cast-iron pipes have been short, and there have been restraints on their commercial development. In spite of these difficulties, the boards have progressed considerably in the development of a co-ordinated and economical system of gas supply, it is stated in the Gas Council's Fifth Report and Statement of Accounts for the year ended March 31, 1954, which was issued recently together with the annual reports of the area boards and of the Minister of Fuel and Power.

By improved working methods, by replacing obsolete plant and by closing down small and uneconomic works, the efficiency of production at gasworks has improved from 71 per cent. in 1948 to 75·2 in 1954. By improvements in productive efficiency and by administrative economies, all the area boards have succeeded in passing on to consumers only part of their increased costs. Gas is being increasingly used throughout industry. During the year 1953 to 1954, there was an increase of 1·4 per cent. in manufacturing capacity to a total of 11,552,100 therms a day, and the gas industry as a whole had a net surplus of £2,111,536—only a small margin, as the chairman of the Council has pointed out, compared with the gross revenue of £297·4 million.

Although during the past year supplies of steel and cast-iron piping have been more plentiful, the supplies and costs of coal "have continued to cause the Council grave concern." The insufficient allocations of coal necessitated the increased use of water gas, more expensive to produce and reducing the quantity of coke available for sale. For this reason the Gas Council are considering particularly means for reducing the gas industry's dependence on coal.

Research and development is therefore primarily concentrated on improvements in orthodox carbonising techniques, research on the gasification of weakly-caking coals which are in better supply, the production of gas from sources other than coal, a search for natural gas, and improvements in utilising gas and coke.

The search for natural gas is perhaps the most interesting of these projects, with a promise of spectacular gains if it should prove successful—as has been the case in Northern Italy. It is, however, too early to predict the outcome of this investigation, which is being carried out by the D'Arcy Exploration Company, Limited. Deep drilling at Crowborough, Sussex, has resulted in small "shows" of gas at 800, 950 and 1,100 ft., but further drilling down to 2,500 ft. is required to prove whether there is an appreciable quantity of gas. Deep drilling has also been carried out at Cousland, Midlothian, and preliminary survey work has been undertaken in the East Riding of Yorkshire and in Lincolnshire.

Among other research projects, the investigation of processes for the complete gasification of coal continued to be the largest single item on the programme. By the end of the year, tests on the gasification of coke and semi-coke had started in a recently-installed Lurgi-type generator at the Birmingham Research Station, and investigations continued on the gasification of powdered coal, fluidised techniques and the

development of the hydrogenation reaction for gas enrichment.

Other investigations include the production of gas from oil by the interaction of heavy oil and highly superheated steam; the purification and recovery of by-products by ultrasonic and other means; improving refractory materials; disposal of gasworks' effluent; domestic utilisation and industrial applications of gas; and flame and combustion studies—important in view of the growing availability of methane from coal mines, liquefied petroleum gases, and tail gases from oil refineries.

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ENGINEERING HISTORY

A Liberal Education for Engineers

The importance of the history of engineering as a subject in the curriculum of technical students was stressed by Mr. S. B. Hamilton when he delivered his presidential address to the Institution of Structural Engineers on Thursday, October 7. History, commented Mr. Hamilton, studied with even a little imagination, immediately raised questions which carried inquiry far beyond the subject matter from which it stemmed. Almost any student could have his curiosity aroused by historical questions, the answers to which explained what he now did in his own job and why he did it in a particular way; he would also then know of methods which had been tried but discarded in the light of later developments. As a source of information, the new President recommended the *Transactions* of the Newcomen Society.

It was not suggested that history should become an examination subject for intending engineers; but its introduction as a subject of study would have far-reaching beneficial consequences and go far to provide that liberal element in technical courses, the absence of which was so often, and justly, deplored.

* * *

REFINERY EXPANSION AT ANTWERP

New Catalytic Cracker Brought on Stream

It has been announced that work has been completed on the new Houdriflow catalytic cracking unit for Albatross S.A. Belge pour le Raffinage de Petrole at their refinery at Antwerp, Belgium. The contractors have been Head Wrightson Processes, Limited, Teesdale House, 24-26 Baltic-street, London, E.C.4, together with the Houdry Process Corporation and the World Commerce Corporation, both of New York. The consultants for the refinery company were Petrocarbon Limited, 24 Clarendon-road, Manchester.

The new cracking unit, which has a capacity of 3,600 barrels per day, will produce a high-octane petrol and forms an important part of the current expansion and modernisation schemes for the refinery. First brought into commission in 1935, the refinery was badly damaged and was inactive during the war; the original plant was reconstructed in 1948. Last year, in addition to the cracker, construction was begun on a new crude-distillation unit, a feed-preparation unit, a gas recovery and stabilisation unit, plant for the polymerisation of light olefines to be produced in the cracker, and new facilities for treating straight-run and catalytic petrols. At present, the refinery is able to process daily 10,000 barrels of Persian Gulf crude oil but the expansion work in hand and now planned will increase this figure to 15,000 barrels.

PERSONAL

MR. N. E. ROWE, C.B.E., D.I.C., B.Sc., A.C.G.I., M.I.Mech.E., M.Inst.T., F.R.Ae.S., Whit.Ex., technical director, Blackburn and General Aircraft, Ltd., Brough, East Yorkshire, is the President-elect of the Royal Aeronautical Society, 4 Hamiton-place, London, W.1, and will take office as President at the annual general meeting to be held on May 5, 1955.

PROFESSOR S. J. DAVIES, D.Sc.(Eng.), Ph.D., M.I.Mech.E., who occupies the Chair of Mechanical Engineering at University of London, King's College, Strand, W.C.2, has been appointed Dean of the Royal Military College of Science, Shrivenham, Wiltshire. Professor Davies will remain at King's College until the end of the present academic year.

SIR ALEXANDER R. TODD, D.Sc., M.A., F.R.I.C., F.R.S., Professor of Organic Chemistry at the University of Cambridge, has accepted an appointment as Arthur D. Little visiting professor of chemistry at the Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A., for the current autumn semester.

MR. J. W. ELLIOTT, C.B.E., F.C.I.S., chairman of Swan, Hunter, and Wigham Richardson Ltd., and SIR JAMES MCNEILL, K.C.V.O., C.B.E., M.C., M.I.N.A., F.R.S., deputy chairman and managing director, John Brown and Co. (Clydebank) Ltd., have been re-elected, respectively, President and Vice-President of the Shipbuilding Conference for the year 1954-55.

LORD DERWENT has been appointed chairman of the British Road Federation, 4A Bloomsbury-square, London, W.C.1, in succession to LORD SANDHURST.

MAJOR-GENERAL SIR JOHN N. KENNEDY, G.C.M.G., has been elected a director and chairman of Cowans, Sheldon & Co., Ltd., Carlisle. He succeeds MR. J. B. PEARSON, who relinquished the position a year ago after 40 years of service with the firm.

MR. L. D. GOLDSMITH, B.Sc., A.R.C.Sc., F.R.I.C., manager of the Battery Works, Witton, Birmingham, of the General Electric Co., Ltd., has retired after 39 years of service with the company. His successor is MR. J. A. WALTERS, previously manager of the G.E.C. special products department at the head office.

MR. H. W. ROBERTS, A.M.I.E.E., manager of the Blackburn branch of the General Electric Co., Ltd., has retired and has been succeeded by MR. H. F. NORTH, formerly branch engineer at Sheffield.

MR. D. F. WALTON, local director of Thos. W. Ward, Ltd., Albion Works, Sheffield, has been appointed a director of the Ketton Portland Cement Co., Ltd., a subsidiary company of Thos. W. Ward, Ltd.

MR. A. H. PLEWS has been elected managing director of Slack, Sellars & Co., Ltd., saw manufacturers, Sheffield, a subsidiary company of the Neepsend Steel & Tool Corporation, Ltd., Sheffield.

MR. F. C. PYMAN, managing director of William Gray & Co., Ltd., West Hartlepool, is to retire next year. He joined the company in 1911.

Consequent on the retirement of MR. F. A. A., MENZLER chief development and research officer London Transport Executive, 55 Broadway, S.W.1, several changes have been made. The post of chief development and research officer is discontinued. MR. A. T. WILFORD, director of research, now reports to the Executive through the chairman. MR. H. E. STYLES, superintendent of laboratories is appointed an officer of the Executive, retaining his existing title. MR. J. D. C. CHURCHILL, planning officer, now reports to the secretary. Two changes are also reported in the office of the new works engineer. MR. E. W. GAIN, B.Sc.(Eng.), A.M.I.C.E., and MR. J. E. W. HANSCOMB, L.R.I.B.A., have been appointed principal executive assistants.

MR. E. WATERWORTH, chief buyer for the British Tyre and Rubber Group of Companies, Herga House, Vincent-square, London, S.W.1, has retired after more than 40 years of service.

MR. D. W. THOMAS, previously supplies director, Monks & Crane Ltd., Stanhope-street, Birmingham 12, has been made joint managing director with MR. E. C. MARTIN. MR. A. H. BARTON, previously commercial manager, and MR. V. G. EYRE, previously general sales manager, have been appointed to the board of directors.

MR. A. J. BETTS, A.M.I.E.E., has been appointed general sales manager, Enfield Cables Ltd., Victoria House, Southampton-row, London, W.C.1.

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BUSINESS CHANGES

Two old manufacturers of nuts and bolts in the North of England are linked in the acquisition of the interests of EDWARD MERCER LTD., Hollinwood, near Oldham, by SAMUEL MARSDEN & SON LTD., Altrincham Street, Manchester. MR. F. LORD, managing director of Samuel Marsden will continue to direct the sales policy of the companies, and MR. A. MERCER, who joins the Samuel Marsden board, will be responsible for sales at Hollinwood.

The merger between PERMALI LTD., Gloucester, and HORDERN-RICHMOND LTD., Haddenham, Buckinghamshire, has now been completed.

RUBERY, OWEN CO., LTD., Darlaston, South Staffordshire, have acquired the share capital of SHORROCK SUPERCHARGERS LTD., Coventry, a former subsidiary company of Massey-Harris-Ferguson (Sales), Ltd.

LIQUID SYSTEMS LTD., Craig's Court House, 25 Whitehall, London, S.W.1, have signed a contract with BOWSER INTERNATIONAL INC., U.S.A., BOWSER INTERNATIONAL LIMITED, London, and Rubery, Owen & Co., LTD., Darlaston, to manufacture and distribute, under licence, the Bowser filtration and lubricating systems and accessories.

THE ELECTRIC CONSTRUCTION CO. LTD., Bushbury Engineering Works, Wolverhampton, have established a factory for the manufacture of their products at Duncanville, Vereeniging, Transvaal, South Africa.

* * *

OBITUARY

We regret to record the deaths of:

MR. HENRY JAMES DEACON, B.Sc.(Eng.)(Lond.), M.I.Mech.E., M.I.P.E., on September 29, at the age of 56. He was a member of the general manufacturing department of Standard Telephones and Cables Ltd., Connaught House, Aldwych, London, W.C.2, which he joined at the end of 1923.

MR. ROBERT HENRY COVERLEY, C.B.E., at Derby, on October 13, at the age of 69. He was formerly experimental superintendent, Rolls-Royce Ltd., Derby, and later controller of Rotol Ltd., Gloucester. Prior to that appointment, Mr. Coverley had had 30 years with Rolls-Royce Ltd., on the production, design, and development of aeroplane engines. He retired in 1947.

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BRITISH EUROPEAN AIRWAYS

Report on 1953 Working

The introduction of the Viscount air-liner into service with British European Airways in April, 1953, was the outstanding event of the financial year, it is stated in the annual report of the Corporation for the year ended March 31, 1954 (H.M. Stationery Office, 5*s*.). The Viscounts have played a large part in securing increased traffic for the Corporation, who carried in all 29 per cent. more passengers between the United Kingdom and Europe than in the previous year, as compared with 9 per cent. more carried by all the other major scheduled air-lines operating over European routes. Operating mainly over the longer routes, Viscount aircraft carried 146,454 passengers, earned £3,150,000 of revenue, and made a net profit of £301,000.

During the year, B.E.A. carried in all 1,656,779 passengers, 6,582 tons of mail, and 14,559 tons of freight. The total of 53·6 million load-ton-miles was 23 per cent, higher than that of the previous year, and was achieved with 100 per cent. safety. The "sales appeal" of the new Elizabethan and Viscount air-liners resulted in a higher revenue load factor.

Although for the first time in its history the Corporation made a small operating surplus—£64,000, as compared with a loss of £450,000 the previous year—during the year B.E.A. had to provide for an increase of nearly £500,000 in aircraft amortisation charges, with the result that the net deficit for the year was £1,773,797, compared with £1,459,131 in the previous year.

At present B.E.A. make losses on all routes with sector distances less than 260 miles. The problems of short-haul operations with acute seasonal traffic peaks, the report states, call for special techniques, including aircraft specially designed for the job. The new high-capacity adaptable lay-out Viscount V.802, due to come into service in 1956, is expected to contribute to solving these problems.

BRITISH TRANSPORT ENGINEERING

CIVIL, MECHANICAL AND ELECTRICAL WORK COMPLETED AND PLANNED

A summary of those parts of the British Transport Commission's annual report for 1953 which touch on engineering aspects of rail, road and canal transport is given here. Editorial comment will be found in Weekly Survey in this issue.

CIVIL

The net expenditure on maintaining the permanent way and all structures of British Railways during the year 1953 was £62·6 million, representing 16 per cent. of the total working expenses of the railways. To arrive at the total expenditure on civil engineering and building work incurred by the Transport Commission as a whole must be added the £3·6 million spent by London Transport and the sum of nearly £2 million spent by British Road Services on road-haulage premises. The last-mentioned figure —that for building costs of improvements to the Road Services' garages—is described as being " small in relation to what is needed."

On the railways, nearly £2 million of the £6·4 million spent on capital works was devoted to the running lines and included what is officially described as the " betterment resulting from the substitution of flat-bottom for bull-head track," as well as improvements to drainage and some " widenings and additions."

The most important project authorised during the year under review was the completion of the widening of the main line bewteen New Barnet and Potters Bar, and this work is now well under way. This main line out of King's Cross suffers from several " bottlenecks " where four tracks converge to two, the most serious of which occurs south of Potters Bar and is nearly three miles long; the new work involves the construction of new double-line tunnels, the reconstruction of Hadley Wood station and the installation of colour-light signalling on the four tracks. It is hoped that passenger-train punctuality in the area will be improved, but, more significant, the widening is an indispensable preliminary to a more intensive freight service for the industrial communities now being established at the new or enlarged towns of Welwyn Garden City, Stevenage, Hitchin and Letchworth.

Two other schemes approved during the year, in each case at a cost expected to be about £1 million, were for the motive-power depots at Crewe North, where the existing depot is to be modernised, and at Thornaby where a new yard is to be established to deal with the freight traffic required for the still ever-developing iron, steel and chemical industries along Tees-side. Work was also completed during 1953 on the Woodhead Tunnel, the largest main-line railway-tunnel project of the century in Great Britain.

Within the London area, the most interesting prospect is Route " C," the proposed deep-level tube cutting across the existing network of underground railways from Walthamstow in the north-east suburbs to Chelsea and Wimbledon in the south-west. The route, originally devised by the London Plan Working Party in 1949, would establish a direct link in the central area between the main line termini of King's Cross, St. Pancras, Euston and Victoria as well as to other underground railways. The cost of the new tube is put at between £50 to £60 million. It is pointed out, however, that since the existing tubes, constructed at much lower levels of costs than now prevail, are not self-supporting, the new tube, " desirable and essential as in many ways it is," could not pay its way.

Under the heading of " Technical Development and Research," note is made of the introduction of a new ballast-cleaning machine, and the number of special tracklaying crane units was doubled; additional orders for more of these machines were also authorised. A hydraulic re-railing device to be used in confined spaces such as within tunnels and below bridges was also submitted to trials. The effective cleaning of brickwork before re-pointing was undertaken by using a high-pressure jet of water with detergents so that surface dirt and deteriorated material in the joints were removed; the brickwork was then pointed by pneumatic injection. Research programmes were concerned with track fastenings and concrete sleepers, stress measurements in bridges and other structures, and the de-icing of rails. The year 1953 also witnessed the opening of the new hydraulic research laboratory at Southall for the Docks and Inland Waterways, where experiments are to be made on pneumatic breakwaters for harbour entrances and on the towing resistance and wash set up by barges moving along narrow canals.

MECHANICAL

The greater use of Diesel multiple-unit trains, and improvements in the coupling and braking of freight wagons, are two important aspects of mechanical engineering on British Railways which emerge from the report. Further expenditure which has been authorised since the end of 1953 will lead, it is stated, to a more widespread use of Diesel multiple-unit trains in Great Britain than obtains on any other railway system in the world. As well as in the West Riding of Yorkshire, these trains will be used in Lincolnshire and East Anglia, and on the Newcastle-Middlesbrough, Newcastle-Carlisle and Edinburgh-Glasgow lines.

There are several advantages to this form of traction. It offers the benefits of electrification without the need for heavy capital expenditure, and it can be brought into operation as soon as the manufacturing shops can deliver the vehicles, whereas electrification generally requires a much longer time. The trains are clean, they have good acceleration and can be turned round quickly at terminals. One-man operation is practicable, and any number of twin-car sets can be coupled together under the control of one driver. For passenger traffic of the heaviest density, it is pointed out, electrification will probably always retain an advantage, but for many important services, particularly cross-country routes, Diesel multiple-unit trains offer a combination of the advantages of both steam and electricity. The original conception of the Diesel rail-car was that of a " bus on rails," for branches and other lines of light traffic, but on most small rural branch lines which are under consideration for closing there is little prospect of stimulating the traffic. Nevertheless, the possibility of using a limited number of special lightweight Diesel trains of simple construction and reduced first cost on some branches is being pursued. The Watford-St.Albans branch has been selected for a prototype service with four-wheeled lightweight Diesel rail-cars, coupled together in short trains.

The complete change from steam to Diesel shunting in the most important railway yards is proceeding. During 1953, the first locomotives were delivered of the 573 Diesel-electric shunters which have been authorised for construction within five years. By the end of the year the total number of Diesel-electric locomotives had increased by 41 to 242; of other Diesel locomotives by 8 to 14, and of electric locomotives (mostly for the Manchester-Sheffield scheme) by 7 to 65. A sum of £4·1 millions was spent during the year on new locomotives, mainly of standard steam types. The total locomotive stock fell during the year from 19,184 to 18,966, but within the total it is noticeable that the number of mixed-traffic engines went up while the number of passenger and freight engines fell. The percentage of locomotives under or awaiting repair at the end of the year has been improved substantially. The figure was 7·0 in 1947; it fell to 5·1 by 1949 and remained at this percentage until the end of 1953, when it was brought down to 4·9. The report makes brief references to the two gas-turbine locomotives which are in use, and to the coal-burning gas-turbine locomotive which is being built, but makes no comment.

The output of coaching vehicles in 1953 fell short both of requirements and of workshop capacity, owing, indirectly, to general steel shortage in 1952. The output represented a replacement of only about 2 per cent. of the total stock of 57,000 (i.e., at this rate, vehicles would be in use for 50 years). A much higher rate of production is expected in 1954.

The year's construction of wagons and brake vans totalled 40,820, but as with coaches this was less (by 12,000 wagons) of the available building capacity. Four-wheeled wagons are still considered the most suitable for merchandise traffic on British Railways, but for mineral traffic there has been a gradual increase in wagon capacity to the latest 24½-ton wagons (of which 650 were built during 1953), the largest carrying units which can be accommodated on four wheels. Larger wagons, mounted on bogies, are not regarded as economic except for special purposes.

The cost of fitting continuous brakes on all freight wagons and on locomotives not at present equipped was estimated in 1950 to be about £35 millions. Such a conversion would give higher speeds of freight-train movement; it would improve the punctuality of all types of trains; and the potential capacity of the lines would be increased, thereby avoiding capital expenditure and providing improved facilities. Experiments are continuing with regard to the best form of continuous brake for possible standardisation, despite the difficulties arising from the general use of short-wheelbase four-wheel wagons and the problem of finding a suitable coupling. The 162,000 grease-lubricated wagons, which at present obstruct the smooth operation of marshalling yards because of their high rolling resistance, will be replaced within the next few years. Further study has been given to the design of an oleo-pneumatic buffer for wagons. For research into the riding qualities of vehicles a new apparatus has been devised. The detailed design of an experimental equipment for handling road/rail containers without cranes has been completed.

With regard to automatic train control, large-scale trials have been carried out and certain components redesigned. As soon as the Chief Inspecting Officer of Railways is completely satisfied as to the efficiency and reliability of the system, the Commission will be prepared to consider financial authority required for any further development, though they do not consider it would be wise to give automatic train control absolute priority over all other devices for safety.

On London Transport, experience gained in the running of more modern rolling stock made it possible to increase the distance run by each car between overhauls from 200,000 to 250,000 miles. Economies in the fuel consumption of the Executive's buses were made by the use of low-viscosity engine oils. Investigations were carried out with molybdenum disulphide, a solid lubricant which may be of use for certain purposes; the manner in which it can be applied has been studied and service tests were made on trolleybuses. Particular attention has been paid to the possibility of reducing the capital and operating costs of the provincial and Scottish buses by the use of lightweight chassis and bodies, and also lightweight vehicles with chassis and body integrated.

ELECTRICAL

Electric traction receives cursory attention in the report. This is not surprising, for of the 51,607 route miles of standard gauge which were open for traffic in 1953 only 2,405 miles were electrically operated. Of these, 2,137 miles were worked on the low-voltage direct-current

system with conductor rail and 218 miles on the high-voltage direct-current system with an overhead line.

Work on the electrification of the Manchester-Sheffield-Wath line reached an advanced stage during the year. It has recently been opened for passenger traffic, as recorded in ENGINEERING. The changeover of the electric power supply on the Southern Region from 25 to 50 cycles and the alterations which will be required on the same system before 10-car electric trains can be introduced are noted. It is not expected, however, that these works will be finished until 1957 and it is therefore intended to plan extensions of electrification so as to fit in with the present activities of the staff and to enable the specialist teams to be kept together.

A scheme which was put forward in 1946 by the former Southern Railway, for the elimination of steam traction from an area east of a line from Reading to Portsmouth, was reviewed; and the preparation of up-to-date estimates of the cost, which is expected to be in the neighbourhood of £34 million, was put in hand. It will involve the electrification on the third-rail system of the principal lines and the use of Diesel locomotives or rail-cars on the secondary lines.

During the year the scheme for electrifying the London, Tilbury and Southend line was further developed, and an extension of the present electrified line between Liverpool Street and Shenfield to Chelmsford and Southend (Victoria) was authorised. This is planned to come into operation before electrification of the line from Fenchurch Street to Southend (Central). The possibility of electrifying the Eastern Region suburban lines between London and Enfield and Chingford was reviewed. It is pointed out, however, that if this conversion is carried out it will attract additional traffic on the heavily loaded Central tube at Liverpool Street. A solution of this difficulty would be the construction of the Route C tube, to which reference is made in the civil engineering section of this summary.

An equally ambitious scheme which has been "on the drawing board" for many years is the electrification of the main lines of the Eastern Region from King's Cross to Hitchin and Letchworth, a line on which the need for better train services is becoming increasingly urgent. With the removal of the existing bottleneck at Potters Bar, this conversion has been made "easier to contemplate" and high priority must, it is considered, be given to it in any plans for further London suburban electrification. A scheme for the electrification of certain routes in the Glasgow suburban area was also examined.

Tests continued on the Lancaster-Morecambe-Heysham line to solve certain problems in connection with the use of 50-cycle alternating current traction. Electrical operation of the passenger service began in August, 1953, when it was found that interference was being caused to the reception of television. Probable means of preventing this have been discovered.

Useful information was obtained about the design and lubrication of pantograph current collection and γ-ray photography was employed to investigate the behaviour of cable joints in service. With the object of reducing the costs of further electrification schemes, several lengths of experimental overhead equipment were in course of erection on the Manchester-Sheffield-Wath line.

* * *

NEW SMALL SUBMARINES

The first of a new series of small submarines of an improved type has recently been built by Vickers-Armstrongs Limited, Barrow-in-Furness, for the Royal Navy. Designated the X.51, the vessel is about 54 ft. in length and is propelled by Diesel and electric machinery; the prime mover has been supplied by F. Perkins Limited, Peterborough. She will have a complement of five and was launched on October 1.

These vessels are being built mainly for training and testing purposes.

Letters to the Editor

INSPECTION OF CRANES AND HOISTS

Difficulties with Enclosed Working Parts

SIR, As a member of a company chiefly engaged in carrying out the regular examination of lifting equipment to comply with the requirements of the Factories Act, 1937, and other statutory requirements, I write to call the attention of manufacturers and users of lifting appliances to a matter which is causing grave concern to our inspecting staff.

There is a growing tendency on the part of designers to enclose as far as possible all working parts of lifting machinery, including many important load-carrying parts which have to be examined regularly. This feature of design is excellent from the point of view of appearance, lubrication and protection, and the guarding requirements of the Factories Act requires such enclosure of working parts. Nevertheless, this has greatly increased the difficulties of surveyors who must examine, according to the Factories Act, 1937, Section 24, "All such parts and working gear . . . whether fixed or movable," at regular intervals. This involves, in many cases, the complete dismantling of machines at great inconvenience to the user.

I feel that this difficulty would be overcome if manufacturers could be persuaded to incorporate easily removable inspection covers on all enclosures containing load-carrying parts of lifting appliances. This would not involve any major modification of design, and would have other obvious advantages in the interests of maintenance. We are advocating this feature in our day-to-day contacts with users of lifting appliances with the view that, if purchasers of lifting appliances look for this advantage when selecting their requirements, the manufacturers will hasten to satisfy their wishes.

Yours faithfully,
M. F. BARNES, A.M.I.Mech.E.
Chief Engineer.
Inspecting Engineers, Limited,
59 Calthorpe-road,
Birmingham 15.
October 11, 1954.

A MODERN STEAM ENGINE

The N.R.D.C.-Ricardo Design

SIR, I refer to the description in ENGINEERING (October 1, page 442), of the N.R.D.C.-Ricardo steam-operated prime mover, and in particular to the valve gear which is shown in sections A-A and B-B of the drawings on page 443.

Since there is only a single cut-off valve common to both cylinders, it would appear necessary for this valve to operate twice in each revolution of the engine. A careful study of the drawings suggests that this valve lifts once in each revolution of the camshaft, that is, with the same frequency as the steam inlet valves, namely, once in each revolution of the crankshaft. I should be very grateful if this point could be clarified as there may be some other feature in the design which is not brought out in the drawings, or which I have failed to grasp.

Yours faithfully,
W. L. COATS.
11, Croham Mount,
South Croydon,
Surrey.
October 15, 1954.

[The reciprocating motion of the cut-off valve is of the same frequency as that of the steam inlet valves and corresponds to the rotation of both the camshaft and the crankshaft. Steam is supplied to the inlet valves through two recesses in the cut-off valve head and each recess governs the point of cut-off for one of the cylinders. Both points of cut-off therefore occur during one rotation of the camshaft.—Ed. E.]

* * *

PRODUCTION OF TITANIUM IN BRITAIN

I.C.I. Plant

Last week, 50 members of the senior technical staffs of the British aircraft industry attended a conference arranged by Imperial Chemical Industries, Ltd., at one of their Birmingham factories to discuss the properties of titanium and its alloys, the problems of handling and joining the material, and questions of its availability. In the course of the conference it was confirmed that the process which the firm have developed uses sodium in the reduction of titanium tetrachloride. Their main plant, which will be in operation within six months, will thus be the first large-scale production unit to operate a process other than that devised by Dr. Kroll, which came into prominence, particularly in the United States, after the war.

After a considerable amount of exploratory work had been done by the General Chemicals Division of I.C.I., it was decided that the reduction of titanium tetrachloride by sodium was the most promising process, especially for British conditions, and that it was likely to give good quality material at a price competitive with that of any other known process. Consequently, although I.C.I. erected, and are working, a titanium plant using the Kroll process (involving the reduction of titanium tetrachloride by magnesium) in order to have some material available, most of their efforts have been directed to the sodium reduction process.

This process in its essentials is not new. In fact, it was the method by which titanium was first isolated. A semi-technical plant was erected in 1953, and a larger pilot plant was erected and started operation early in 1954. The results obtained on these plants have confirmed the early work, both in the quality of the product obtained and in the efficiency of the process, and have also solved many of the problems connected with the design of a large plant. This large-scale plant is being built in the North of England, and, construction having gone according to schedule, it is expected that the first units will come into production in the first half of 1955, and that full production will be reached before August.

Meanwhile the pilot plant has worked steadily, and many tons of material have been produced and sold. The product from the plant is in the form of granules, which can be compressed into pellets for melting. After melting into ingots, the material has a hardness which compares favourably with the product by the Kroll process.

Concurrently with the General Chemicals Division's work on producing raw titanium, extensive research and development work has been done by I.C.I.'s Metals Division on processes for melting and fabricating titanium and its alloys. A pilot plant at one of their Birmingham factories has been melting raw titanium sponge for some time past at the rate of 150 tons per annum, and converting it into ingot, forging stock, and various fabricated products which have been supplied to the aircraft industry. A major plant for the melting and preliminary fabrication of titanium and its alloys will be completed early next year, when supplies of strip, sheet, rod, tube and wire, in addition to raw titanium sponge, ingot, and forging stock, will be available on a large scale.

The capacity of the full-scale plants which are being erected is 1,500 tons a year. Though this capacity may seem small compared with the announced intentions of the American makers, it is not much less than the amount of titanium sponge actually produced in America in 1953 (2,250 short tons), and the plant can be expanded.

(*Editorial comment in Weekly Survey*)

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Electronic Instruments and Equipment. BOULTON PAUL AIRCRAFT LTD., Wolverhampton. Multi-channel recorder; strain gauge bridge; load-ring dynamometers; pressure, displacement and force transducers; counters, timers and integrators; stabilised power supplies; automatic manometers. Illustrated technical leaflets collected together in loose-leaf binder.

Spiral-Tube Coolers and Heaters. SPIRAL TUBE & COMPONENTS CO. LTD., Osmaston Park-road, Derby. Engine coolers, locomotive coolers, industrial coolers, unit heaters of finned-tube construction. Illustrated brochure describing development of firm's activities during 50 years since their founding in 1904.

Oil Burner. PRIOR STOKERS LTD., 1-3 Brandon-road, York-way, London, N.7. Pressure-jet fully-automatic burner for oil with a viscosity of 200 seconds Redwood No. 1 at 100 deg. F. Illustrated leaflet giving technical description and specification.

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LARGE DAMS

British Contributions to Fifth Congress

The following nine papers and two communications are to be presented by the British National Committee at the Fifth Congress of the International Commission on Large Dams of the World Power Congress, which is to open in Paris on May 31, 1955.

On *Question No.* 16, Design and Construction of Dams on Permeable Soils and Methods of Foundation Treatment, three papers will be submitted: "The Gain in Stability due to Pore Pressure Dissipation in a Soft Clay Foundation," by A. W. Skempton and A. W. Bishop of the Imperial College of Science and Technology; "The Treatment by Grouting of Permeable Foundations of Dams," by C. F. Grundy, the Cementation Co. Ltd.; "Stabilising an Earth Dam Foundation by Sand Drains," by G. A. R. Sheppard and A. L. Little, Messrs. Binnie, Deacon and Gourley.

On *Question No.* 17, Economics and Safety of Different Types of Concrete Dams, three papers: "The Employment of Prestressed Technique on Allt-na-Lairige Dam," by J. A. Banks, Messrs. Babtie, Shaw and Morton; "The Design and Economics of Massive Buttress Dams," by E. J. K. Chapman and D. Fraser Campbell, Messrs. James Williamson and Partners; "The Heightening of a Gravity Dam," by C. M. Roberts, Sir William Halcrow and Partners.

On *Question No.* 18, Settlement of Dams due to Compressibility of the Dams Materials or of the Foundation Soil, including Earthquake Problems, two papers: "Difficulty Experienced in the Construction of the Hollowell Dam," Northampton," by J. Kennard, Messrs. Edward Sandeman, Kennard and Partners; and "Some Unusual Foundation Problems Arising from Construction of Dams in Active Volcanic Country," by J. K. Hunter and H. G. Keefe, Sir Alexander Gibb and Partners.

On *Question No.* 19, The Relation of the Cement Content of the Concrete to Performance in Practice of Gravity, Arch and Buttress Dams and its Influence on Permeability and Frost Resistance, one paper: "Concrete Dams in Great Britain: Cement Content in Relation to Performance," by C. R. Lee, Building Research Station, D.S.I.R.

The two following communications will also be submitted by British delegates: "Investigation of Stress Distribution in a Diamond Head Buttress Dam by Photo-elastic Model Tests," by H. G. Keefe, Sir Alexander Gibb and Partners; and "Investigation of Right Angled Bends at the Foot of Vertical Spillway Shafts," by Oscar Elsden, also of Sir Alexander Gibb and Partners.

BOOK REVIEWS

A Statistical Primer. By F. N. DAVID. *Charles Griffin and Company, Limited, 42 Drury-lane, London, W.C.2.* (22*s.*)

This book is the product of a series of lectures which have been given by its author in recent years at University College, London, to mixed audiences of undergraduates and others from nearly all science departments and possessing little in common except an ignorance of mathematics. In these circumstances the potential reader would expect it to provide an introductory treatment with the minimum of mathematical formulæ and the maximum of concrete examples, and this is, in fact, what it does. Although the examples are for the most part taken from the natural sciences, the method of presentation is such that, once the technique is understood, the application in another field of research is immediate. This is an advantage to those approaching the subject for the first time, in that it will enable them to appreciate the scope of the analysis at important stages of the work, as, for example, where the same procedure is applied, first, to a statistical comparison of the heights of Englishmen and Scotsmen and, second, to a study of variation in the tensile strength of two batches of wire ropes which have been supplied by different manufacturers.

Following preliminary remarks on the meaning of variation and aggregates, for which the statistician uses the special word "population," Dr. David proceeds to expound those characteristics of a frequency distribution which are employed to summarise its main features and to permit of comparisons between distributions of the same type. These are known as measures of location, measures of dispersion, measures of skewness and kurtosis, and moments. It is well to have these quantities explained in a simple yet instructive manner, because of their utility in the solution of problems that are likely to be met in practice. The use of moments, for instance, extends throughout the theory of sampling; and in general conditions the set of moments of all orders completely determines the distribution. Of equal importance is the fact that two distributions whose lower moments are equal are approximations, one to the other. Thus in those cases where it is possible to determine the moments without being able to express the frequency function itself explicitly, it is feasible to approximate to the unknown distribution by equating the lower moments to those of a distribution that is known.

Experience as a teacher has shown the author where beginners are likely to go astray, and he has been very successful in elucidating, in Chapters 9 to 17, the various tests of significance which have much to do with statistical sampling. It often happens that observations cannot be taken over a whole population, and that only one sample is available for the purpose. Then the question arises: what can be said of the population on the evidence provided by the solitary sample? If the sample has been chosen in circumstances where bias may operate, it may be impossible to say anything of practical value. But if the sample has been chosen at random, definite statements may be made with measurable degrees of probability of being correct.

Hence it comes about that the theory of probability constitutes an essential part of statistics, and the greater part of sampling is concerned with one or another aspect of statements in probability. Matters relating to certain theoretical distributions which take a central place in nearly all branches of the theory are then discussed, in Chapters 18 to 24, under the main headings of the binomial series, Poisson's binomial limit, the index of dispersion, and the χ^2-test for goodness of fit between observation and hypothesis. Within the limits which Dr. David has prescribed for himself—limits which will be of great benefit to the newcomer to this useful subject—he has done his work so well that it is difficult to see how it could be bettered.

BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Engineering Analysis: An Introduction to Professional Method. By D. W. VER PLANCK and B. F. TEARE, JR. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.; and Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (48*s.*)

This book is written as an aid in the teaching of courses in engineering analysis. Emphasis is on the thinking process, and the form in which the analyses are presented is that which an engineer might use in his own notebook. The subjects treated include material from dynamics of translation and rotation, electric circuits, heat transfer, solution of linear differential equations with constant coefficients, uses of power series, and integration by graphical and numerical methods. To stimulate thinking, there is an extensive collection of problems with no clue given as to the methods of solution.

Electronic Measuring Instruments. By E. H. W. BANNER. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (45*s.*)

For the instrument engineer and the user of measuring instruments, this book provides a guide to the application of electronic technique to specific problems. The book is divided into four parts covering (i) the characteristics of indicating instruments applicable to electronic devices, (ii) electronic devices used in measuring instruments, (iii) electronic instruments using the devices of part (ii), and (iv) quasi-electronic instruments and electronic devices used directly. A feature of the book is a section on radiation measurement, which provides information for the engineer engaged on nuclear research.

Basic Road Statistics, 1954. Great Britain and Northern Ireland. *British Road Federation, 4a Bloomsbury-square, London, W.C.1.* (1*s.*)

This booklet is issued annually with the object of providing a standard reference on all essential road matters. The statistics given include those for motor vehicles, road traffic and accidents, transport industry, roads and road finance, motor taxation and road transport legislation. The figures have been brought up to date as far as possible, the sources of information being quoted in each case.

The Fundamentals of Electric Log Interpretation. By M. R. J. WYLLIE. *Academic Press, Incorporated, 125 East 23rd-street, New York 10, N.Y., U.S.A.* (3·60 dols.); and *Academic Books, Limited, 129 Queensway, London, W.2.* (29*s.*)

This book does not pretend to teach interpretation procedures and techniques in any detail, but is directed to the non-specialist in an oil company, such as the well geologist and the reservoir engineer, who may be called upon to interpret routine and semi-routine logs. Theory and practice of quantitative log interpretation are described, and a summary of logging techniques and their applications is given.

The English Windmill. By REX WAILES. *Routledge and Kegan Paul, Limited, Broadway House, 68-74 Carter-lane, London, E.C.4.* (35*s.*)

Different types of mill and their variations in different parts of the country are discussed, and a detailed account is given of their machinery, how the mills are worked, and the men who operate them. The decline of windmills in England and efforts made to preserve them are also discussed, and the illustrations include those windmills which at present work by wind.

Field Tests on Wood Preservatives used for Pressure Treatment. By D. N. SMITH. Forest Products Research Bulletin No. 32. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.* 6*d.*).

This publication describes the different types of preservative, the nature of the tests and the results so far obtained. Although these are not all complete, the information available indicates the general behaviour of the different classes of preservative, and those most likely to be satisfactory in use.

Residual Stresses in Metals and Metal Construction. Edited by WILLIAM R. OSGOOD. Prepared for the Ship Structure Committee under the direction of the Committee on Residual Stresses, U.S. National Academy of Sciences, National Research Council. *Reinhold Publishing Corporation, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (10 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (80*s.*).

The effect of residual stresses on the performance of various kinds of structures are described, particular

emphasis being placed on the possible contribution of these stresses to fracture. Twenty-two papers, contributed by specialists in the field, provide information on the origin, magnitude and distribution of residual stresses existing in a structure or machine, whether arising from welding, machining or other causes. The book will be of interest to metallurgists, construction engineers, structural designers and those concerned with the strength and stress properties of metals.

Electrical Accidents and their Causes, 1952. Ministry of Labour and National Service, Factory Department. *H.M. Stationery Office, Kingsway, London, W.C.2.* (3*s*.)

This report, which is issued annually, is based on the work of H.M. Electrical Inspectors of Factories. Statistics are given showing the variation of electrical accidents over the past 20 years, and the number of accidents are analysed in relation to employment and to apparatus.

The Institution of Naval Architects Autumn Meeting (*continued from page* 492)

SHAFT APPENDAGES AND SHIP-MODEL CORRELATION

RESISTANCE OF BOSSINGS AND SHAFT BRACKETS

The second paper to be presented and discussed at the first technical session of the Institution of Naval Architects Autumn Meeting at Torquay, held on September 21-24, was that of Mr. H. Lackenby, M.Sc. It formed Part III of the "B.S.R.A. Resistance Experiments on the Lucy Ashton" and dealt with "The Ship-Model Correlation for the Shaft-Appendage Conditions." The work described consisted of a series of trials of the ship with the hull in normal service condition (i.e., with sharp seams, and the hull coated with red-oxide paint) and comparative tests in an experiment tank with six geometrically similar models. The Lucy Ashton was originally a paddle steamer, but suitable twin-screw bossings were fabricated by welding and attached to the hull for the trials, and another set of trials was carried out with shaft brackets in place of the bossings. The author mentioned that the full-scale resistance was also measured with the naked hull in the fouled condition, after various periods of immersion; this work is to be discussed in a later paper. The model tests were carried out in the Ship Division of the National Physical Laboratory, at Teddington, and the models ranged in length from 9 ft. to 30 ft.

SCALE EFFECT

The investigation showed a pronounced scale effect on the resistance increments due to fitting bossings and brackets. In the case of the bossings, it varied gradually over the speed range from zero at the lowest speeds to an appreciable effect at the intermediate and higher speeds, the ship increments being about half those for the models, over the ship's working speed range of 8 to 12 knots. Some previous work with models only, however, had shown no perceptible scale effect with increasing size, at any speed. It was thought that the difference might be due to the fact that, in the Lucy Ashton, the bossing webs were inclined to the undisturbed streamline flow, whereas in the previous experiments mentioned they were aligned with it. In the case of the trials with shaft brackets, the scale effect did not vary with speed, but again, over the working speed range and with the usual model lengths, the ship increments were about half of those measured on the models. Between 8 knots and 13 knots, it was found that brackets offered slightly less resistance than bossings, and that, outside this speed range, the opposite was true; but the differences were small, generally less than 2 per cent. It was thought, however, that if the bossing webs had been aligned with the stream flow, the slight advantage of shaft brackets in the matter of resistance might have been offset. The ship and model results were correlated in terms of total resistance on the Schoenherr basis, as had been done previously for the naked hull. The derived roughness allowances for the hull surface, both with bossing and with shaft brackets, agreed well between themselves and also with those for the original naked-hull condition.

DISCUSSION

The discussion was opened by Dr. S. Livingston Smith, C.B.E., who thought that one of the most comforting features about the results of the investigation was that both the current practices and some of the old practices in the estimation of scale effect on appendage resistance were confirmed, at least to some extent. It was interesting to note that, in way of the service speed, the scale effect for bossings was approximately 50 per cent., a rough and ready figure which had been in use for quite a long time. At the higher speeds, however, the bossing effect was much exaggerated on the model. The evidence that there was some change of flow between model and ship was supported by the difference of running trims on the ship as compared with models. The curves in the paper gave an overall check on the accuracy of all results, including those in the previous papers, and showed the roughness allowances for the ship necessary to complete the ship-model balance. The total agreement between the curves was convincing proof of the overall accuracy of the results. All the time they had been striving for the greatest possible accuracy in the full-scale experiments, and he claimed that they had maintained it. There was no doubt that the results were correct.

Ir. A. J. W. Lap said that he was a little disappointed that such a fine piece of experimental work led only to a rather approximate conclusion, namely, that the increments in ship resistance, due to appendages, were to scale, "roughly one half" of those measured on the models.

He agreed entirely with the analysis given by the author, using only differences between curves of specific resistance, but thought it should be possible to analyse the results further, without having to take into consideration the exactness of any particular resistance extrapolator, by making use of the properties of the modern ship-form frictional-drag curves. As had been pointed out by Dr. Hughes, the effect of form on the frictional-resistance coefficients was proportional to the frictional-resistance coefficients of the corresponding flat plate. Professor L. Troost had shown that the Lap-Troost extrapolator led to almost the same results. In the cases of both bossings and shaft brackets there was a difference in specific resistance with the naked models, not only for the higher speeds, but also for the very low speeds; and that difference tended to decrease for increasing model size. In his opinion, the most likely conclusion from those experimental facts was that different ship-form frictional-drag curves must be used for the different conditions. The differences between the respective frictional-drag curves proved to be 4·5 per cent. of the corresponding Schoenherr frictional-resistance coefficients in the case of the bossing and 6·8 per cent. in the case of the shaft brackets. The Schoenherr extrapolator had been chosen for reasons of easy calculation; the use of any other extrapolator gave only second-order deviations, which might be neglected.

In the case of the shaft brackets it was unlikely that the specific wave-making resistance would change in comparison with the naked-hull condition. Thus the specific resistance coefficients for that case might be "predicted" from the naked-hull results by adding to the total specific resistance of the latter 6·8 per cent. of the corresponding specific frictional resistance. He had done that for all the models and for the Lucy Ashton, and had also plotted the results for the 9-ft., 16-ft. and 30-ft. models as well as for the Lucy Ashton on a base of $\frac{V}{\sqrt{L}}$, together with the actual measured values. The agreement between measured and "calculated" results was striking.

In the case of the bossings aligned in the streamline flow, similar results might be expected. Could the author give some information about the preliminary tests with the 16-ft. model? Bringing the web of the bossing across the flow would result in lift forces which might change the trim of the ship and accordingly the wave-making resistance. In the case of that model family it was possible to add to the individual naked-hull results 4·5 per cent. of the corresponding Schoenherr coefficients. The differences in total specific resistance between those corrected values and the line faired through the actual measured results had been plotted. If they were due to wave-making resistance, they must be independent of the model scale and vary with $\frac{V}{\sqrt{L}}$ only. In his opinion, that condition was fulfilled within the limits of experimental error. A mean line has been drawn through all the spots, giving the increase in wave-making resistance due to the bossings. With the aid of that line and the known correction for difference in ship-form frictional-drag curve, it was possible again to "predict" the results with bossings from the results in the naked-hull condition. Again, the agreement between the predicted and the actually measured values for three models and the Lucy Ashton was striking.

EFFECTIVE METHOD OF RESISTANCE EXTRAPOLATION

He concluded, therefore, that, in the case of the Lucy Ashton model family, the ship-form frictional-drag curves method gave a complete answer as to how the resistance of appendages could be extrapolated. The only thing to do was to carry out experiments at sufficiently low speeds to determine the line $\frac{V}{\sqrt{L}} \rightarrow 0$ and extrapolate the results according to the corresponding ship-form frictional-drag curve. Calculation what the author called "the degree of scale effect," according to the method described gave almost the same results as those in the paper. The application of those modern extrapolators did not contradict the brilliant assumptions of William Froude.

Professor G. Vedeler said that the ship-model correlation made in the previous Lucy Ashton paper had been criticised—he thought rightly—by Dr. Hughes, Dr. Telfer, Dr. Kempf and Professor Troost because the curves drawn did not fit the points of measured values as well as they ought. The curves had been forced into parallelism with the Schoenherr line, notwithstanding the values measured for the 9-ft. model, especially at the lower speeds. A similar criticism applied to the present paper. Professor Troost had tried recently to draw best average curves for all experimental model data given in the previous paper, including 4-ft. and 6-ft. models tested at the Massachusetts Institute of Technology, and reached the remarkable conclusion that "An endeavour to extrapolate these curves to the full-size ship region gave very erratic values for roughness allowance." Dr. Vedeler had no doubt that the same would apply to the results given in the present paper and that, therefore, the curves given in Mr. Lackenby's Fig. 14 should not be regarded as scientifically correct. There were still important unknown questions in connection with ship-model correlation. Kempf's tests with a model of the Lucy

Ashton showed that the ship must have exhibited a considerable amount of eddy-making; and Troost rightly pointed out that there must be a certain amount of interaction or coupling between the wave-making and frictional resistances. It seemed necessary to ask for the assistance of able mathematicians in solving those questions. It was not to be inferred, however, that the figures given by Mr. Lackenby were not sufficiently correct for practical purposes.

VARIATIONS IN SEA-WATER DENSITY

Sir Victor G. Shepheard, K.C.B., said that the well-known difficulty of drawing reliable conclusions from model experiments regarding the resistance of comparatively small appendages was emphasised by the results in the paper. It was an important achievement, therefore, that they now had some reliable information on the actual resistance of shaft appendages as measured on a ship at sea. His own first reaction was to seek the relative merits of the two arrangements. It was not surprising, perhaps, that shaft brackets and shafts created less resistance than bossings at the service speed of 12 knots and that the difference was small—about 1 per cent. of the ship resistance. In dealing with such small differences, the question of accuracy of the ship measurements naturally arose. Great refinement of accuracy was called for to distinguish between the relative merits of the alternative arrangements. For example, an overall accuracy of, say, plus or minus one-half per cent. would be a very high standard, having regard to the conditions of the trial generally, which involved a period between dockings, and other variables for which reliable corrections were difficult. Even if that refined standard were obtained, it was suggested that the only really firm conclusion was that there was little or nothing to choose between the alternative arrangements, as far as resistance was concerned, and that the contribution of each to the total ship resistance was of the order of 4 per cent. at service speed. A small error of the order stated would also go some way to explaining the change in relative merit of the two arrangements at low speed, service speed and high speed. On that question of accuracy, he noticed that the recorded density of the water during the trials varied between 1,007 and 1,021 oz. per cubic foot, i.e., a variation of 1·4 per cent.; also that the density of the water was measured only once on any particular day, whereas he would expect the density of the water in the Gareloch to vary hour by hour, according to the state of the tide, and possibly also to vary along the trial course. Apparently, therefore, adequate correction had not been made to the results to allow for the changing density of the water. Perhaps the author would remark on that point and on the bearing of overall accuracy of measurement on his conclusions.

ALIGNMENT TO FLOW

The author mentioned that the slight resistance advantage of the shaft brackets might have been offset if the bossing webs had been aligned to the flow. It may also be added that some improvement in the shaft brackets would be obtained if the arms were similarly adjusted. In fact, close alignment of the arms would be more readily practicable, as those were relatively local features, whereas the bossings extended over an appreciable length of the hull and appreciable twist might well be required to ensure minimum resistance. The importance attached to the alignment of shaft brackets for H.M. ships had been brought out in Dr. Gawn's paper, it was a practice to be recommended for ships generally. It would not be appropriate to draw general conclusions regarding the relative merits of the alternative shaft arrangements from the results with those in the specific ship dealt with in the paper. Moreover, any assessment must take account of the overall propulsive efficiency. That had been investigated by model experiment for one or two designs. The wake was found to be greater with bossings, so that the position was complicated by the necessity of arranging for the propeller to be of somewhat less pitch than if shaft-bracket arms were fitted. There were also small changes in the increase of resistance and the relative rotative efficiency, but on the whole there was no clear-cut difference between the two arrangements from a propulsive point of view. There was, however, a saving of weight with shaft brackets, which was not without its attraction for the warship designer.

TESTS ON AEROFOILS

Professor E. V. Telfer said that, after the presentation of Mr. Lackenby's previous paper, he had pointed out that, while the author had used the Schoenherr extrapolator and had adopted the device that Dr. Telfer had suggested in 1927, of linearising whatever extrapolator was selected, the 9-ft. model results completely confuted any right the author had to adopt the Schoenherr line as his extrapolator. The only two extrapolators to use were the Hughes extrapolator and his own; both completely confuted the idea of the Schoenherr line being a correct extrapolator. Mr. Lap had said that it was not necessary to have the correct extrapolator in order to glimpse the truth now emerging. That statement was wrong; the extrapolators must be correct throughout the whole of the range. He had looked forward to Mr. Lackenby's results on bossings and shaft brackets with great interest, feeling that they would reveal still more difficult things to explain than did the previous paper. In 1951 he (Dr. Telfer) had pleaded for experimenters to carry out scale-effect tests on bossings, but with controlled types of bossings. He suggested that they need not worry whether a bossing looked like a ship's bossing at all, but should make tests on aerofoils of controllable angles and definite size and lift qualities, placed in the vicinity of shaft bossings or brackets. They could " geosim " them and alter the angle, and see what happened to the total scale effect. A really scientific investigation was needed into the mechanism of shaft-bossing scale effect, because it seemed, on considering the bossing results given in the paper, that there was a real contradiction in extrapolation qualities. At the low speeds there was very little scale effect; at 14½ knots, a considerable amount. That could not be due to any drag changes, and it showed how important it was to test bossings at different angles to the flow in order to see clearly the real mechanism.

LIFT AND SKIN FRICTION

What the 14½-knot line showed, he suggested, was the gradual increase of the lift on the bossing inclined forward, due to the wave angle, combined also with the gradual reduction of the skin friction.

Mr. H. Volpich, B.Sc., said that, though generally the shaft appendage addition was relatively small with respect to the total effective horse-power of a hull form, except for some orthodox cases, both the specialist and the general practitioner in naval architecture were often undecided whether to add the full model value or only a fraction of it to the final naked E.H.P. The recent Lucy Ashton experiments shed new light on that question and there was no doubt, from the evidence derived from the tests, that only 50 to 60 per cent. of the total model addition should be used. Where full bossing was concerned, those recent results were in contradiction to the N.P.L. results published by Dr. J. F. Allan in 1950 in his paper to the Institution of Engineers and Shipbuilders in Scotland, where a series of geosims varying in length from about 18 ft. to 34 ft. showed only negligible scale effect for full bossing. In his contribution to the discussion on that paper, some of the available Dumbarton tank data were analysed, and substantiated the conclusion that there was hardly any scale effect in full bossing. With regard to open shafting and A-brackets: Some full-size tests with struts 10½ in. by 2¾ in. had been run in the Dumbarton tank and the relevant figures checked very well with the data in the present paper.

It was generally agreed that, for shafts and A-brackets, the shafts in themselves were the major contributors to scale effect; it would have been interesting to see the results from, at least, some of the geosims with the total appendage resistance broken up into the two components, shafts and brackets. Although the evidence of scale effect on full bossing was quite convincing from the Lucy Ashton tests, another similar, but perhaps not so ambitious, series would be useful in order to make a final decision on this matter. In the Wageningen tank, extensive geosim tests had been made on the " Victory " ship up to a $\frac{1}{6}$ scale model, the D. C. Endert Jr. If those models were still available, the deadwood aft could be filled in, and full bossing could be fitted to suit twin screws of about 14 ft. 6 in. diameter, with a propeller tip clearance of about 28 per cent. With the propellers abaft station ½ the bossing would be somewhat shorter than in ordinary twin-screw vessels, but would still extend over approximately 1½ stations; that would give a complementary series from $\frac{1}{16}$ to $\frac{1}{6}$ scale of the full-size ship.

Dr. J. F. Allan thought that the paper, while very valuable, was in some ways disturbing. The first point on which to concentrate was the great importance of accuracy and the great difficulty of achieving it when measuring small additions. A troubling point was the different conclusion arrived at as the result of those experiments from the one he had reached on the geosim experiments some years previously. Those experiments were confined to the model range from about 16 ft. to 30 ft. From Mr. Lackenby's paper, in respect of the models in the 16 ft. to 30 ft. range, and assuming no other information was available, it might be accepted that any difference was just that due to skin friction; but the really important feature was that it was clearly established that the ship increment with the bosses and with the " A " brackets was of the order of 50 per cent. of that measured on the models within the scale range used. It was very important that further work should be done on that subject. It would be a mistake to draw the general conclusion that bossing scale-effect was of the order of 50 per cent. as between the model and the ship. The Lucy Ashton was a vessel of very shallow draught, and the bossing apparently had quite a marked effect on the wave formation at the after end of the ship, an effect which would not exist with the A-bracket.

AUTHOR'S REPLY

Mr. Lackenby, replying to the discussion, said that Dr. Livingston Smith had referred to the rather convincing evidence of consistency in Fig. 14; there was even more convincing evidence of that in Part IV of the series of papers, which would shortly be published. He was quite convinced that the accuracy and consistency were remarkably close. He thought that there was too much concentration on skin friction extrapolation; it was not all skin friction. There was such a thing as separation of flow, especially with small models. It did not follow that the model resistance result was wrong or that Schoenherr's skin-friction line was wrong, but there was an indication in connection with the 9-ft. model of some other factor which they did not know. He doubted the wisdom of trying to make ship-model experiments on very tiny models of about 1 ft. long; he was not sure that there was in such cases skin friction plus waves, but rather skin friction plus waves plus eddy flow, which did not happen on the bigger models or on the ship. Dr. Vedeler suspected that the curves in Fig. 14, although they seemed to agree very closely, might not be scientifically exact; but they did come near enough for practical purposes, and he emphasised that the investigation was intended to be a really practical one. Dr. Allan thought it dangerous to conclude from the paper that the difference of increment for bossings was 50 per cent. For bossings it was not 50 per cent., although in the case of the shaft bracket it was 50 per cent.

To be continued

LARGE FORGINGS

PRODUCTION, TESTING, FORGING PLANT

A joint meeting between the National Forgemasters' Association and La Chambre Syndicale de la Grosse Forge Française was held at the Iron and Steel Institute, London, on October 11, 12 and 13. The meeting opened on October 11 with a reception. The first technical session was held on Tuesday, October 12, when after speeches of welcome by the Hon. R. G. Lyttelton, President of the Institute, and Mr. F. Pickworth, chairman of the National Forgemasters' Association, two papers were presented.

ULTRASONIC INSPECTION

The first paper, entitled " Problems in the Manufacture and Ultrasonic Inspection of Heavy Upset Steel Forgings," was by Mr. C. Roques, Mr. Charles Dubois and Mr. P. Bastien, of the Forges et Ateliers du Creusot. The authors stated that their main object had been to investigate the nature of the defects revealed by ultrasonic testing and, if possible, to determine their cause so as to assist the forging shop to devise remedial measures.

The defects found consisted most frequently of minute cracks, and subsequent micrographic inspection had shown that, in many cases, these were located in what had previously been interdendritic spaces in the structure of the steel. In some forged discs there was evidence of a direct relation between these defects and sulphide inclusions. In a runner made of ball-bearing steel, the defects had been found to extend into the carbide bands resulting from the interdendritic segregation of the chromium and the carbon in the steel. Such carbides were likely to play the same role as inclusions in view of their poor solubility in austenite. Further work had suggested that it was the simultaneous presence of heavy strains and of inclusions which gave rise to a tendency to crack formation.

THERMAL STABILITY TESTING OF ROTOR FORGINGS

In the second paper, on " Reversible Deformation During the Thermal Stability Testing of Rotor Forgings," Dr. H. H. Burton and Mr. J. E. Russell, of the English Steel Corporation, Limited, Sheffield, stated that the thermal stability testing of rotors for high-temperature service had now become standard practice. The tests consisted of supporting the rotor on its end journals, or in centres, heating the body portion uniformly while rotating the rotor slowly and taking measurements of the distortion. The test temperature was usually 50 deg. F. above the designed operating temperature of the rotor, and the rotor was usually considered to be satisfactory if the difference in eccentricity between the " hot " and the " cold " readings was less than 0·001 in. For a good rotor the distortion seldom exceeded about 0·0003 in. Bad distortion, however, could occur if the rotor had been machined immediately before testing or if the rotor initially contained unrelieved internal stresses.

CONTINUOUS GRAIN-FLOW PROCESS

The first paper considered at the afternoon session on October 12 was by Mr. P. Verot, of the Ateliers et Forges de la Loire, Saint-Chamond, who dealt with recent applications of the continuous grain-flow process. He stated that the process involved the forging of a crankshaft, crank by crank, starting from a rolled or forged bar on which the webs were upset simultaneously with the forging of the cranks. The method eliminated the necessity for hot torsion and enabled important savings of weight to be obtained on rough pieces. It had now been extended to the manufacture of aeroplane-propeller hubs. The two, three, or four arms of the propeller hubs were hollow forged in a special machine having double, triple or quadruple action. The mechanical characteristics obtained in the hub arms in the longitudinal direction were much improved as compared with other methods. The crankshaft forging equipment could also be used for making, by upsetting, the coupling flanges on long shafts as well as the flanges of crankshafts. The mechanical strength of the upset flanges was much greater than that of flanges obtained by normal forging, and the process also enabled the use of smaller-section ingots.

FORGE FURNACES

Two papers on forge furnaces were then presented and discussed jointly, and in the first, Mr. L. Bailly, of Anseremme, Belgium, stressed the need for the closer control of temperature and atmosphere in heating steel stock for forging or drop forging and advocated the increased use of insulating refractories and low-inertia metallic recuperators to secure improved thermal efficiency. In the second paper, Dr. F. W. Jones and Mr. A. Barker, of the Brown-Firth Research Laboratories, gave the results of theoretical calculations carried out to find the soaking time required to give a degree of temperature uniformity, adequate for forging, in ingots of between 20 in. and 100 in. ruling section, heated at various rates.

FORGING HAMMERS AND PRESSES

At the last technical session of the meeting, held on the morning of Wednesday, October 13, four papers were presented, the first two dealing, respectively, with the production of a large reaction vessel at the Creusot Works, and with trepan boring with tungsten-carbide tipped tools at the works of Walter Somers, Limited. In each case, the methods were discussed.

The two last papers were presented jointly, the first dealing with the new Firminy forging shop of the Ateliers et Forges de la Loire, and the second, with a 35,000 ton die-forging press for light alloys. The author of the first paper, Mr. G. Bois, forge manager at Firminy, said that the heaviest machine in the new shop was a 1,200-ton high-speed hydraulic vertical Eumuco four-column press designed for cogging down ingots using a 5-ton Wellman manipulator or travelling cranes. The press was served by two static-hearth and a bogie-hearth reheating furnaces. Other equipment in the shop included a 5-ton and a 50-cwt. arch-form double acting hammers. The shop, which came into production in February, 1954, could forge ingots having a maximum weight of about 12 tons.

Mr. J. G. Frith, of the Davy and United Engineering Company, Limited, was the author of the paper on the press for light alloys. He stated that it had a power of 35,000 short tons and had been designed and was now under construction at the Pittsburgh Works of the United Engineering and Foundry Company, Pennsylvania, U.S.A. The press was intended for the production by die-forging of structural members for aircraft frames and wings. It had eight main cylinders arranged in pairs, each pair being mounted in an individual entablature member between two of the eight forged-steel columns. The press could be operated at $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, or full power. The platen was 24 ft. long by 12 ft. wide, and the clear daylight between the upper and lower bolsters was 15 ft. The main cylinders had a stroke of 8 ft., and the total overall height of the press was 76 ft., some 20 ft. of this being below floor level. Four lifting cylinders were fitted and these were designed to act as equalising cylinders when the work being done necessitated the press load being applied off centre. The permissible eccentricity, with full press power, was 2 ft. off centre along the length of the press and 1 ft. off centre across the press. The press would be operated by hydraulic pumps in conjunction with an air-hydraulic accumulator.

RESEARCH ON CAST IRON

The Work of B.C.I.R.A.

The recognition that dust is not a feature inseparable from foundry work and that it can be controlled and eventually, to a large extent at all events, eliminated, is perhaps one of the most important developments in the metal-melting industry during the past few years. The British Cast Iron Research Association, Alvechurch, Birmingham, have taken a leading part in the work on dust control, and it is stated in their recently issued 33rd annual report, for the year ending June 30, 1954, that the section of the Association's development department dealing with foundry atmospheres is pursuing an active programme of work on the elimination of dust from the knock-out sections of foundries. An extensive schedule has been laid down to determine the critical air contours required to control dust " plumes " under widely varying shop conditions. Work is still going forward to control the dust produced not merely by conventional pedestal grinding machines, but also by portable hand and swing-frame grinders. Moreover, an investigation has been made of factors affecting the rate of cooling of sand, and the effect of moisture on the evolution of dust from foundry sand. Preliminary work has also been carried out in connection with the problem of the external pollution of the atmosphere from cupola furnaces, a question of considerable importance to foundries situated near to residential areas.

Research work has continued on defects arising from the vitreous enamelling of iron castings. Actual temperature cycles obtained in industrial furnaces have been determined in the laboratory. The evolution of gases during the enamelling cycle is being studied by heating samples in a stream of purified argon and analysing the gases evolved by means of an infra-red gas analyser. An investigation has been carried out on the cracking of iron bath castings, as a result of which a correlation has been obtained between the percentage of cracked castings and the amount of enamel scrap contained in the cupola charges. Cracking appears to be promoted by the " pick-up " of antimony, boron and lead by the metal of the charge from the enamel scrap.

FATIGUE OF NODULAR CAST IRON

A preliminary programme of work on the fatigue properties of nodular cast irons of various silicon contents, in the as-cast and heat-treated conditions, has been completed. Fatigue tests have been conducted on hardened and tempered nodular irons and on nickel-free nodular irons. The galvanising embrittlement of blackheart malleable cast iron and temper embrittlement in nodular cast iron have been the subject of an extensive investigation.

The application of the vacuum-heating method for the determination of hydrogen in cast iron has been studied and suitable apparatus constructed. The results show that hydrogen is rapidly evolved just below and well above the critical temperature range and that the evolution of hydrogen is more rapid with white than with grey irons. Apparatus has also been developed for a study of the evolution of hydrogen at room temperature, and it has been found that hydrogen is evolved continuously over periods of up to at least 200 days.

Work has continued on the influence of graphitisation on the rate of decarburisation in malleable cast iron. Manganese and sulphur play an important part, but the results appear to be influenced by any prior heat treatment received by the metal. A co-operative study on the production of sound test bars in malleable cast iron is proceeding. A survey on the problem of hot tearing in white-iron castings is also in hand. Another survey, in this case a preliminary one, has been made of the problems involved in reducing or removing the high phosphorus content of British pig irons.

WAVE ACTION IN DIFFUSERS FOR PIPE SYSTEMS

SCAVENGING TWO-STROKE ENGINES

By F. J. Wallace, PH.D., B.SC.

It has been appreciated by designers for some time that by incorporating a divergent duct—variously referred to as a diffuser or megaphone—in the exhaust system of an engine, a distinct improvement in the scavenging characteristics may be obtained. Such megaphones are frequently fitted to small motor-cycle engines, particularly of the racing type, but also to much larger stationary engines. While the mode of action of these devices is understood broadly in qualitative terms, a quantitative estimation of the processes occurring within the diffuser presents considerable difficulties, and a solution sufficiently simple and convenient to appeal to engine designers has not, hitherto, been found.

In qualitative terms the diffuser is a device for utilising in the most effective possible manner the energy—both kinetic and potential—associated with the pressure waves propagated in the exhaust duct of an engine. In contrast to a plain parallel pipe, where a considerable amount of energy is inevitably rejected to the atmosphere during reflection of pressure waves at the open end of the duct, the diffuser offers two distinct advantages.

A pressure wave entering the diffuser is gradually reduced in amplitude, thereby suffering a simultaneous decrease in potential and kinetic energy. This energy is, however, imparted to the waves which result from continuous partial reflection of, and move in opposition to, the main pulse propagated through the diffuser to the open end. If the diffuser is correctly designed, almost the entire energy content may be imparted to the returning train of reflected waves, in which form it assists materially in the scavenging of the cylinder contents, while only a very small fraction of the original energy is rejected to the atmosphere.

PROLONGED SCAVENGING ACTION

The second advantage derives from the fact that, owing to the continuous reflective action of the diffuser, as opposed to the instantaneous action of a plain open end, the total period during which scavenging waves arrive at the exhaust ports is considerably prolonged. This factor may lead to a further improvement in scavenging characteristics.

The physical nature of the processes occurring within the diffuser is extremely complex. A comparison with the much simpler case of wave reflection and superimposition in a parallel duct* will make this point clear. Not only is there continuous superimposition of wave trains moving in opposite directions, as in the parallel pipe, but there is also the effect of the geometry of the duct which, with large angles of divergence, becomes of paramount importance. The attenuation of waves in diffusers is extremely severe, and there is a very pronounced tendency for the initially unsteady flow to approximate to steady flow after traversing only a comparatively short distance inside the diffuser.

REFLECTED WAVES IN CONICAL DUCTS

Fig. 1 shows a conical diffuser, the semi-angle of divergence being α and the diameter of the parallel pipe to which the diffuser is joined being D. The distance from the diffuser entry section to the apex of the diffuser cone produced is d, while the length of the diffuser is L.

The fundamental equations governing the flow in the diffuser are those of continuity, momentum and energy.

* F. J. Wallace. "The Superimposition of Plane Waves of Finite Amplitude." ENGINEERING, vol. 172, page 423 (1951).

If u, p, ρ refer to the dependent variables of velocity, pressure and density, respectively, while s and t denote respectively the independent variables distance and time, the former being measured from the diffuser entry section, and the latter from some arbitrary and convenient datum, these three equations may be written as follows:—

Continuity equation:

$$u\frac{\partial \rho}{\partial s} + \rho\frac{\partial u}{\partial s} + \frac{\partial \rho}{\partial t} = -\rho\frac{u}{A}\frac{dA}{ds}, \quad . \quad (1)$$

where A is the cross-sectional area of the duct at a distance s from the diffuser entry section.

Momentum equation:

$$u\frac{\partial u}{\partial s} + \frac{\partial u}{\partial t} + \frac{1}{\rho}\frac{\partial p}{\partial s} = 0. \quad . \quad . \quad (2)$$

Energy equation:

$$u\frac{\partial p}{\partial s} + \frac{\partial p}{\partial t} - \frac{\gamma p}{\rho}u\frac{\partial \rho}{\partial s} - \frac{\gamma p}{\rho}\frac{\partial \rho}{\partial t} = 0, \quad (3)$$

where γ is the ratio of the specific heats at constant volume and constant pressure of the gas.

It is assumed that there is no interchange of energy between the gas in the diffuser and the atmosphere, through the walls.

WAVE SYSTEM CHARACTERISTICS

These partial differential equations of the first order may be shown to constitute a hyperbolic system,* solutions of which are possible only along certain definite lines, known as characteristics. There are two families of these characteristics, one for waves moving to the right, and the other for waves moving to the left. The equations of the characteristics may most conveniently be derived by converting equations (1), (2) and (3) into finite difference equations. Thus, with reference to Fig. 2, if 1 and 2 are two points on a characteristic for a rightward-moving wave, along which state conditions are known, and u_1, p_1, ρ_1 and u_2, p_2, ρ_2 represent the known states 1 and 2, while u, p, ρ, represents the unknown state at point 3 on a neighbouring characteristic, then if it is assumed that

$$\frac{u-u_1}{\Delta s} \simeq \frac{\partial u}{\partial s}, \quad \frac{u_2-u}{\Delta t} \simeq \frac{\partial u}{\partial t}, \text{ etc.,}$$

equations (1), (2) and (3) become

$$u\frac{\rho-\rho_1}{\Delta s} + \rho\frac{u-u_1}{\Delta s} + \frac{\rho_2-\rho}{\Delta t} = -\rho u\frac{1}{A}\frac{\Delta A}{\Delta s}. \quad . \quad (1A)$$

$$u\frac{u-u_1}{\Delta s} + \frac{u_2-u}{\Delta t} + \frac{1}{\rho}\frac{p-p_1}{\Delta s} = 0. \quad (2A)$$

$$u\frac{p-p_1}{\Delta s} + \frac{p_2-p}{\Delta t} - \frac{\gamma p}{\rho}u\frac{\rho-\rho_1}{\Delta s} + \frac{\gamma p}{\rho}\frac{\rho_2-\rho}{\Delta t} = 0. \quad (3A)$$

Determinantal expressions for u, p and ρ may be deduced in the manner of an ordinary, linear, algebraic system, from equations (1A), (2A) and (3A).

Thus $u = \frac{Z_1}{N}$, $p = \frac{Z_2}{N}$, $\rho = \frac{Z_3}{N}$,

where Z_1, Z_2, Z_3 and N are determinants, which still contain the dependent variables u, p and ρ.

Now along a characteristic the expressions for u, p and ρ must be indeterminate, since these quantities can be defined only when associated with a second characteristic belonging to the second family. This condition of indeterminateness is fulfilled by simultaneously equating the numerator and denominator to zero.

Thus, putting $N = 0$:

$$\begin{vmatrix} u\Delta t - \Delta s & \frac{1}{\rho}\Delta t & 0 \\ \rho\Delta t & 0 & u\Delta t - \Delta s \\ 0 & u\Delta t - \Delta s & -\frac{\gamma p}{\rho}u\Delta t + \frac{\gamma p}{\rho}\Delta s \end{vmatrix} = 0,$$

which, reverting to differentials, gives the solutions:

$$\frac{ds}{dt} = u, \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$\frac{ds}{dt} = u \pm \sqrt{\frac{\gamma p}{\rho}} = u \pm a, \quad (5)$$

where a is the acoustic velocity. Equation (4) refers to particle velocities and equation (5) to propagation velocities, for waves moving to the left and right, respectively.

Putting $Z_1 = 0$ and writing

$$u_2 - u_1 = \Delta u \simeq du$$
$$p_2 - p_1 = \Delta p \simeq dp$$
$$\rho_2 - \rho_1 = \Delta \rho \simeq d\rho$$

Then:

$$\begin{vmatrix} -du & \frac{1}{\rho}dt & 0 \\ \frac{\rho}{A}\frac{dA}{ds}dt - d\rho & 0 & u\,dt - ds \\ a^2 d\rho - dp & u\,dt - ds & -a^2(u\,dt - ds) \end{vmatrix} = 0$$

Substituting for $\frac{ds}{dt} = u \pm a$ from equation (5), this determinant ultimately reduces to

$$du = -\frac{1}{a}\frac{dp}{\rho} - \frac{a}{A}u\frac{dA}{ds}dt. \quad (6A)$$

$$du = +\frac{1}{a}\frac{dp}{\rho} + \frac{a}{A}u\frac{dA}{ds}dt. \quad (6B)$$

* Jenny E., "Berechnungen und Modellversuche über Druckwellen Grosser Amplitude." Thesis submitted for degree of Doctor of Engineering (1949), Technische Hochschule, Zürich.

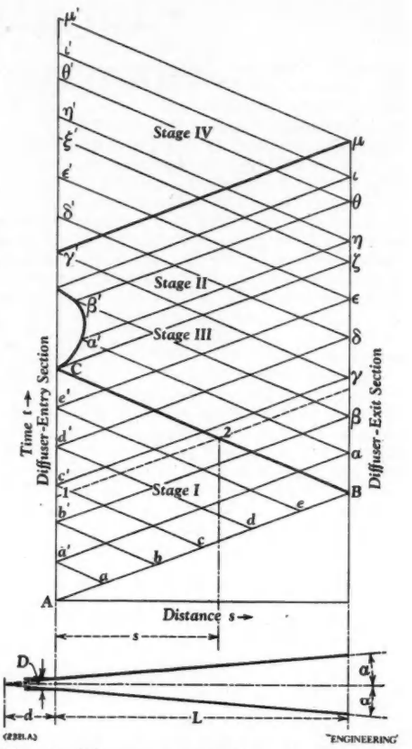

Fig. 1 Diagram representing stages in the propagation and reflection of wave trains in a conical diffuser. Diffuser performance is governed by the parameter L/d.

Equations (6A) and (6B) refer to waves moving to the right and left, respectively.

DIFFUSER DESIGN CHARTS

The integration of equations (6A) and (6B) along characteristics involves extremely lengthy step-by-step calculations or graphical constructions. Moreover, it is quite impossible to make any general deductions concerning the behaviour of diffusers from any one example calculated in this manner, whereas the designer requires precisely such general data in order to decide on the most efficient type of diffuser for a particular application. By making certain warrantable assumptions it is possible to arrive at an analytical solution of equations (6A) and (6B), from which such general deductions may readily be made and which may be represented very conveniently in chart form.

These assumptions are as follow: (i) All changes of state are considered isentropic so that, if p_0, ρ_0, a_0 refer to the pressure, density and acoustic velocity at a datum level (usually atmospheric pressure and temperature are selected for the reference quantities), then the density and acoustic velocity at some other pressure p are respectively given by

$$\rho = \rho_0 \left(\frac{p}{p_0}\right)^{\frac{1}{\gamma}}$$

which simplifies, if γ is taken to be 1·4 and a quantity x is chosen such that $x = \left(\frac{p}{p_0}\right)^{\frac{\gamma-1}{2\gamma}}$, to

$$\rho = \rho_0 x^5 \quad \text{and} \quad a = a_0 x.$$

(ii) All disturbances are propagated with the acoustic velocity $\pm a_0$, instead of the true velocity $\frac{ds}{dt} = u \pm a$, given by equation (5). This assumption is justified in view of the rapid decay of the particle velocity, u, in the diffuser, and is further supported by the results of step-by-step calculations. (iii) In certain cases the pressure ratio x, i.e., $\left(\frac{p}{p_0}\right)^{\frac{1}{7}}$, may be taken as unity.

With the above assumptions and given $dt = \pm\frac{ds}{a_0}$, equations (6A) and (6B) become, respectively,

$$du_R = -5\,a_0\,dx_R - \frac{2\,u_R}{d+s}\,ds. \quad (7A)$$

$$du_L = +5\,a_0\,dx_L - \frac{2\,u_L}{d+s}\,ds. \quad (7B)$$

where the suffixes R and L refer to rightward and leftward waves, respectively, and

$$\frac{2}{d+s} = \frac{dA}{ds}\Big/A.$$

VELOCITY AND PRESSURE DISTRIBUTION IN DIFFUSER

A general solution now follows

$$u_R = \frac{C_1}{s+d} + \frac{C_2}{(s+d)^2}. \quad . \quad (8)$$

$$x_R = \frac{C_2}{s+d} + C_4. \quad . \quad . \quad (9)$$

for rightward waves, and

$$u_L = \frac{D_1}{s+d} + \frac{D_2}{(s+d)^2}. \quad . \quad (10)$$

$$x_L = \frac{D_2}{s+d} + D_4. \quad . \quad . \quad (11)$$

where C and D are constants chosen so as to satisfy the given boundary conditions.

Furthermore,

$$C_3 = \frac{C_1}{5\,a_0} \quad \text{and} \quad D_3 = -\frac{D_1}{5\,a_0}.$$

It may be shown that the constants C and D for rightward- and leftward-moving wave trains are inter-related and not independent of each other.

Two wave trains represented in Fig. 1 by the lines 1-2 and B-2 start respectively at the diffuser-entry section and at some point inside the diffuser and coincide at the point 2, distant s from the entry section.

The changes in particle velocity along 1-2 and B-2 are given by integration of equations (7A) and (7B), respectively. By use of the integrating factor

$$I = e^{\int \frac{2}{s+d}ds} = (s+d)^2,$$

and re-arranging

$$u_2(s+d)^2 - u_1 d^2 = -\int_0^s 5\,a_0 \frac{dx_R}{ds}(s+d)^2\,ds = 5\,a_0\,C_3\,s. \quad . \quad (12)$$

(The value of x_R is obtained from equation 9.) And similarly for wave B-2

$$u_2(s+d)^2 - u_B(L+d)^2 = -5a_0\,D_3\,s. \quad (13)$$

Subtracting equation (12) from (13)

$$u_1 d^2 - u_B(L+d)^2 = -5\,a_0\,s\,(D_3 + C_3),$$

or

$$D_3 = -C_3 + \frac{u_B(L+d)^2 - u_1 d^2}{5\,a_0\,s}. \quad (14)$$

Furthermore, since $C_3 = \frac{C_1}{5\,a_0}$

and $D_3 = -\frac{D_1}{5\,a_0}$,

$$D_1 = C_1 - \frac{u_B(L+d)^2 - u_1 d^2}{s}. \quad (15)$$

The above equations imply that, while it is possible to choose the constants C_1, C_2, C_3 and C_4 for any wave moving to the right so as to satisfy a given set of boundary conditions, the corresponding constants D_1, D_2, D_3 and D_4 for a wave moving to the left and crossing the original wave are functions both of the position, where crossing occurs, and of the constants C_1, C_2, etc., which in turn depend on the boundary conditions of the rightward-moving wave.

INTER-RELATION OF COUNTER-MOVING WAVE TRAINS

Hence it is not strictly possible to evaluate the constants D for a wave moving to the left in terms of its boundary conditions in such a way as to satisfy at the same time the conditions obtaining during its superimposition on successive wave trains moving in the opposite direction. In fact, the values of D_1, D_2, etc., are changing continuously during the propagation of the wave and a rigorous estimation of pressure and velocity changes is only possible with the aid of step-by-step methods.

It may, however, be shown that for a wide range of conditions the error incurred by integration of equation (7B) in terms of a single set of constants D based on the boundary conditions at the instant of initiation on the one hand, and at the instant of crossing the diffuser-entry section, on the other, is small.

If the particle velocity at the diffuser-entry section is u_e, while at a distance s from that position it is u_s, substitution in equation (8) gives the following values for the constants C_1 and C_2:

$$C_1 = \frac{u_s(s+d)^2 - u_e d^2}{s}. \quad . \quad (16)$$

$$C_2 = \left[\frac{u_e d - u_s(s+d)}{s}\right](s+d)\,d. \quad (17)$$

The constants D_1 and D_2 for a wave travelling to the left are given by similar expressions.

The particle velocity and pressure ratio at the diffuser-entry section—which will be referred to as the boundary conditions—are influenced by changes both upstream, that is in the parallel section of the duct, and downstream, that is in the diffuser itself.

BOUNDARY CONDITIONS

Thus, when determining the boundary conditions for a particular wave emerging from the diffuser and about to enter the parallel section of the duct, two characteristic equations have to be considered, namely, that appertaining to the above wave moving to the left and given by equation (7B), and secondly the characteristic equation of the wave moving in the opposite direction and emerging from the parallel duct at the same instant. If u_1 and x_1 denote the initial particle velocity and pressure ratio, respectively, of this latter wave the characteristic equation may be written:

$$du = -5\,a_0\,dx,$$

or, by integrating, and substituting the boundary conditions u_e and x_e:

$$u_e - u_1 = -5\,a_0\,(x_e - x_1). \quad . \quad (18)$$

By substituting a value of the velocity u obtained from equations (10), (16) and (17) in equation (7B) the characteristic equation of the wave emerging from the diffuser is obtained. It is

$$u_e - u_s' = 5\,a_0\,(x_e - x_s') - \int_{s'}^{0} \frac{2\,u}{s+d}\,ds,$$

$$= 5\,a_0\,(x_e - x_s') - 2\int_{s'}^{0}\left\{\frac{u_s(s+d) - u_e d^2}{s(s+d)^2} + \frac{[u_e d - u_s(s+d)]\,d(s+d)}{s(s+d)^3}\right\}ds,$$

$$= 5\,a_0\,(x_e - x_s) + 2\left\{\frac{u_s(s'+d)^2 - u_e d^2}{(s'+d)\,d}\right\} + \left\{\frac{u_e d - u_s(s'+d)}{(s'+d)\,d}\right\}(s'+2d). \quad . \quad . \quad . \quad . \quad (19)$$

where $0 < s' < L$, and s' is the point of initiation of the leftward-moving wave.

Equations (18) and (19) may be solved simultaneously for u_e and x_e, the required boundary conditions at the diffuser-entry section.

These values are, however, only approximate for the following reason.

The derivation of equations (8) and (10) for the velocity distribution in the diffuser was

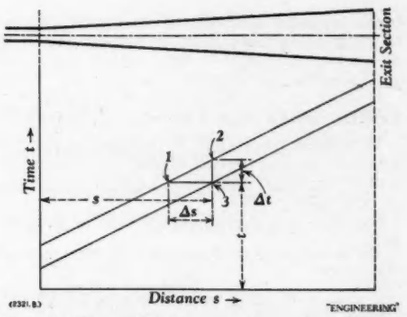

Fig. 2 Characteristic equations for diffuser conditions are obtained by converting equations of continuity, momentum and energy into finite difference equations as this construction indicates.

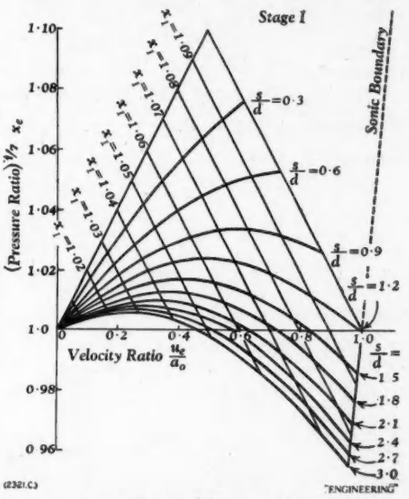

Fig. 3 Chart representing boundary conditions at the diffuser entry (stage I).

based on the assumption of a constant velocity of propagation for all wave points, such that $\frac{ds}{dt} = \pm a_0$.

CORRECTION FOR PARTICLE VELOCITY

With increasing values of the particle velocity u this assumption entails appreciable errors and a more accurate, if less convenient, solution has to be sought.

Since the true propagation velocity is given by $\frac{ds}{dt_R} = u + a$ for a wave travelling to the right and $\frac{ds}{dt_L} = u - a$ for a wave travelling to the left the characteristic equations (7A) and (7B) may more accurately be written:

$$du_R = -5\,a_0\,dx - \frac{2\,u\,a_0}{(a_0 + u)\,(s + d)}\,ds. \quad (20)$$

and

$$du_L = 5\,a_0\,dx - \frac{2\,u\,a_0}{(a_0 - u)\,(s + d)}\,ds. \quad (21)$$

respectively.

Considering the case of a wave moving to the left and substituting for $u_L = \frac{D_1}{s+d} + \frac{D_2}{(s+d)^2}$ from equation (10)

$$u_e - u_{s'} = 5\,a_0\,(x_e - x_s)$$
$$- 2\,a_0 \int_{s'}^{0} \left\{ -1 + \frac{a_0}{-\frac{D_1}{s+d} - \frac{D_2}{(s+d)^2} + a_0}{(s+d)} \right\} ds$$

which ultimately reduces to:

$$u_e - u_{s'} =$$
$$5\,a_0\,(x_e - x_{s'})$$
$$+ a_0 \log_e \left\{ \left[\frac{d^2}{(s'+d)^2} \right] \left[\frac{a_0\,(s'+d)^2 - D_1\,(s'+d) - D_2}{a_0\,d^2 - D_1\,d - D_2} \right] \right\}$$
$$- \frac{D_1}{2\sqrt{W}} \log_e \left\{ \left[\frac{d - \frac{D_1}{2\,a_0} - \sqrt{W}}{d - \frac{D_1}{2\,a_0} + \sqrt{W}} \right] \left[\frac{(s'+d) - \frac{D_1}{2\,a_0} + \sqrt{W}}{(s'+d) - \frac{D_1}{2\,a_0} - \sqrt{W}} \right] \right\}. \quad (22)$$

where

$$W = \frac{D_2}{a_0} + \frac{D_1}{4\,a_0^2}$$

and D_1 and D_2 are given by expressions corresponding to equations (16) and (17).

Since these expressions also include the unknown velocity u_e at the diffuser-entry section, and since they appear in logarithmic terms in equation (22), it follows that this latter equation does not yield an explicit solution for u_e. The most convenient procedure is to find an approximate solution for u_e from equations (18) and (19), and then, with further calculations based on this approximate value, to obtain by iterative methods a value satisfying the more stringent conditions imposed by equation (22). Equation (18) is again used in conjunction with equation (22) to eliminate the unknown pressure ratio, x_e.

This approach has been adopted in the derivation of the boundary charts, Figs. 3, 4 and 5.

ANALYSIS OF WAVE REFLECTION

Having considered the derivation of the fundamental equations governing changes of state inside the diffuser, the process of wave reflection must now be considered as a whole. It is convenient to subdivide the process into a number of distinct stages, which are numbered in chronological order.

With reference to Fig. 1, it can be seen that stage 1 extends from the instant of arrival of the incident wave at time t_0 (point A) up to the return of the first train of reflected waves from the open end of the diffuser (point C) or, alternatively, up to the instant of initiation of supersonic conditions, whichever is the earlier. This stage is marked by the arrival at the diffuser-entry section of a series of wave trains reflected from the head of the original wave in the course of propagation to the open end, and indicated in Fig. 1 by aa', bb', cc', etc. The boundary conditions along AB are characterised by $u = 0$, $x = 1$. The first boundary chart (Fig. 3) applies to this stage.

Stage II commences when the head of the original wave arrives at the open end of the diffuser. During this stage successive waves arrive at the open end from the diffuser-entry section (points α, β, γ, etc.) and are reflected in the opposite direction. The boundary conditions at the open end are characterised by $x_0 = 1$, while the velocity u_0 is governed by the particle velocity (u_e) and pressure ratio (x_e) associated with the same wave point at the instant of crossing the diffuser-entry section. The boundary conditions for different values of L/d at the open end are represented in the second boundary chart (Fig. 4). When a wave point, after reflection at the open end of the diffuser, emerges once again at the entry section, its particle velocity (u_e') and pressure ratio (x_e') are functions of the initial pressure ratio (x_1') of a wave point travelling in the opposite direction along the parallel section of the pipe and emerging at the diffuser-entry section at the same instant, as well as of the particle velocity (u_0) as given by the boundary chart of Fig. 4. This third set of relationships—u_e' and x_e' in terms of u_0 and x_1'—is represented in the third boundary chart (Fig. 5).

SUPERSONIC CONDITIONS

Stage III is characterised by the initiation of supersonic conditions at the diffuser-entry section. A pressure discontinuity is created due to the fact that disturbances propagated from the open end of the diffuser towards the entry section cannot be transmitted across this supersonic region. A shock wave is formed and persists until, owing to a general decrease in particle velocity associated with a reduction in amplitude of the incident wave, disturbances can once again proceed freely from the open end of the diffuser across the entry section. The processes occurring during this period are extremely complex and it has not been found possible to extend the present treatment to this special case. The case is, however, of small practical importance since very considerable wave amplitudes are required for the initiation of supersonic conditions. The demarcation line between subsonic and supersonic conditions is indicated in the first and third boundary charts (Figs. 3 and 5).

Stage IV persists from the instant of arrival of the tail of the fundamental pulse at the diffuser-entry section up to the end of the reflection process. The whole of this stage is characterised by the condition $x_1' = 1$, but is otherwise similar to stage II, and therefore, represented by the third boundary chart (Fig. 5).

APPLICATION OF BOUNDARY CHARTS

The significance of the boundary charts may best be illustrated by their application to some practical cases. Three different diffusers have been selected for this purpose, with leading dimensions as shown in Table I.

Each of these diffusers is assumed to be attached to a considerable length (more than 4 ft.) of parallel pipe of internal diameter 1⅜ in., the latter communicating directly with the exhaust ports or valve of an engine. For simplicity, and also to illustrate more clearly the

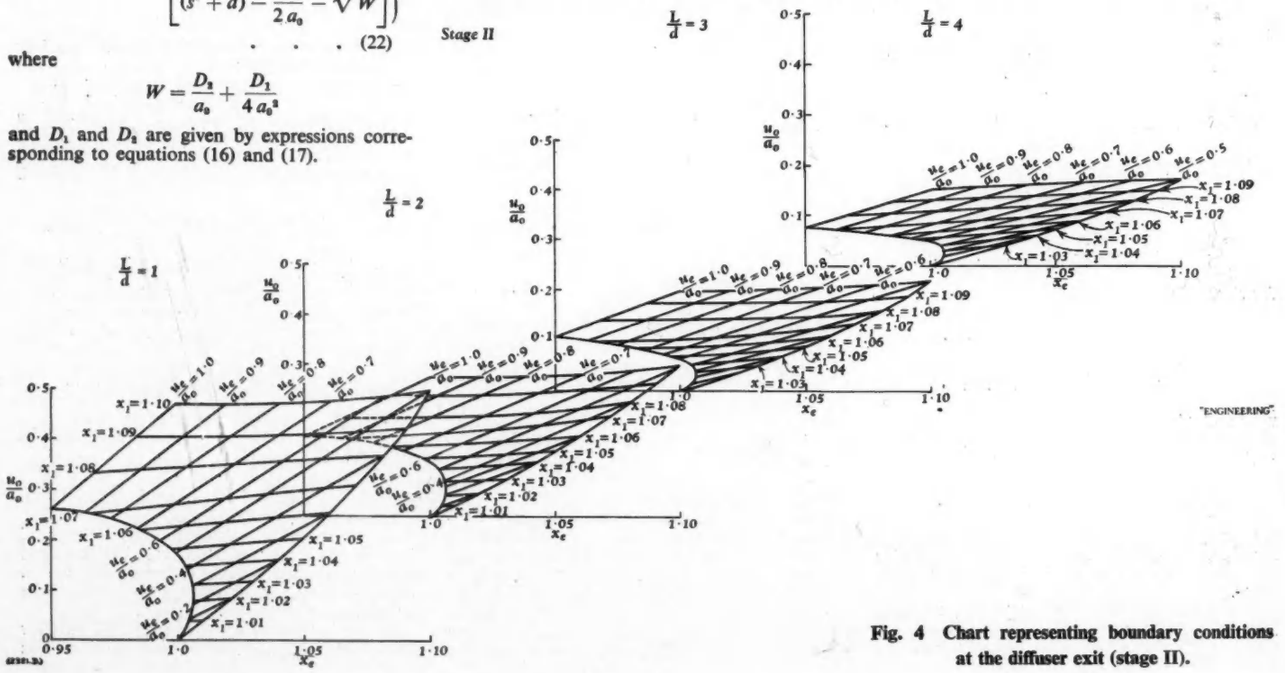

Fig. 4 Chart representing boundary conditions at the diffuser exit (stage II).

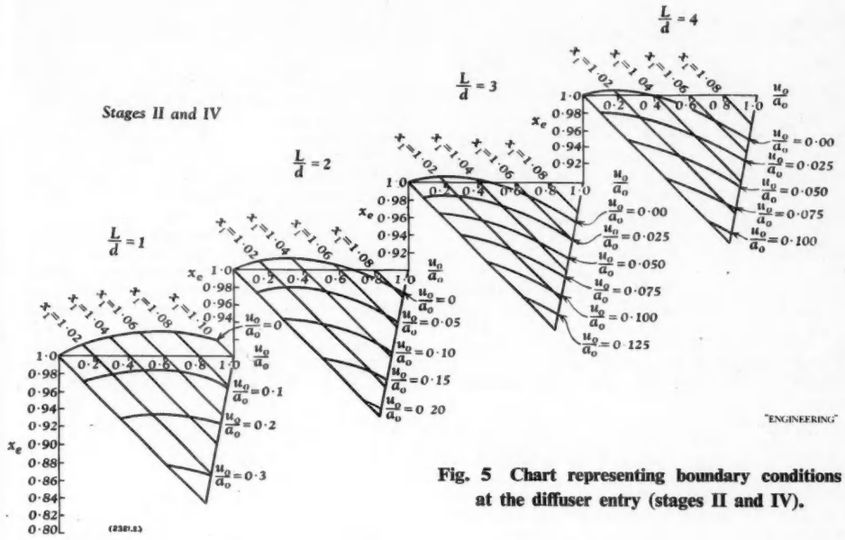

Fig. 5 Chart representing boundary conditions at the diffuser entry (stages II and IV).

differences arising from the use of these three diffusers, the form of the fundamental exhaust pulse as recorded at the diffuser-entry section is assumed to be sinusoidal, and its amplitude and duration are identical for the three cases.

The pressure ratio $\left(\frac{P_{max.}}{P_0}\right)^{\frac{1}{7}} = x_{max.}$ is taken as 1·05, giving a peak amplitude of 6·2 lb. per square inch gauge at an atmospheric pressure of 14·7 lb. per square inch. The duration of the pulse is taken as 10 milliseconds

TABLE I.—*Dimensions of three diffusers selected for analysis*

Diffuser	Length L (ft.)	Diameter at entry Section (in.)	Semi-angle of Divergence (deg.)	Distance d (ft.)
1	4	1⅜	6·55	1
2	4	1⅛	3·28	2
3	2	1⅛	6·55	1

or 36 crank degrees at an engine speed of 600 r.p.m. An approximate value of 1,000 ft. per second has been assigned to the acoustic velocity at atmospheric pressure to simply the calculations. In a firing engine 1,700 ft. per second would be a more appropriate value.

The fundamental-pulse amplitude ratio at any time t may now be expressed analytically in the form

$$x_1 - 1 = 0{\cdot}05 \text{ sin. } (100\,\pi\,t)$$

Using the notation of the boundary charts, but introducing in addition the symbols u_e', x_e' and x_1' to denote conditions at the diffuser-entry section during stages II and IV, and the symbol x_r to denote the gross pressure ratio of the reflected wave emerging from the diffuser-entry section at any particular instant, Tables II, III and IV may now be drawn up.

Fig. 6 illustrates the net-pressure ratio of the reflected wave and the net or recorded pressure (due to superimposition of the incident and reflected waves) obtaining at the diffuser-entry section for the three diffusers specified earlier. The corresponding pressure ratios with a 4-ft. plain parallel pipe of the same length fitted in place of the diffusers and those for a parallel pipe 2 ft. long are indicated by the o-link dotted lines.

IMPROVED SCAVENGING PULSE

Fig. 6 demonstrates the very marked gain in amplitude and duration of the returning rarefaction wave resulting from the use of diffusers instead of a plain parallel pipe. A very considerable depression occurs during the first 3 milliseconds of the period under consideration although with a parallel pipe, the formation of a depression cannot begin until the head of the original pressure pulse has been reflected at the open end and returned to the indicating point after a period of approximately 8 milliseconds. This period corresponds to stage I as previously defined. During the remaining 10 milliseconds the magnitude of the depression created by the diffusers exceeds all the corresponding values obtained with a parallel pipe. The differences in amplitude between cases 1 and 2 during this second period are, however, comparatively slight.

It is immediately apparent that during stage I diffuser 1 with its large angle of divergence is considerably more effective than the second diffuser. This is due to the very rapid attenuation of the fundamental pulse in the first case, resulting in the simultaneous formation of a rarefaction wave of considerable amplitude moving in the opposite direction. During stages II and IV the relative positions are reversed; here, diffuser 2 is rather more efficient than diffuser 1, but the gain does not compensate for the loss during stage I. It might be concluded that the angle of divergence should therefore be increased indefinitely. This, however, is erroneous since large angles of divergence lead to violently turbulent flow, a considerable proportion of the pulse energy being absorbed in frictional reheat. Similarly, although an increase in the length of the diffuser would appear

TABLE II. QUANTITIES REPRESENTING THE CONDITIONS IN DIFFUSER 1 AT INTERVALS OF ONE MILLISECOND

Time (secs. × 10^{-3})	x_1	$\frac{s}{d}$	x_e	$\frac{u_e}{a_0}$	x_1'	x_e'	$\frac{u_e'}{a_0}$	x_r
0	1·0	·0	1·0	0	—	—	—	1·0
1	1·0161	0·50	1·0128	0·096	—	—	—	0·9967
2	1·0294	1·00	1·0176	0·204	—	—	—	0·9882
3	1·0405	1·50	1·0160	0·324	—	—	—	0·9755
4	1·0476	2·00	1·0100	0·424	—	—	—	0·9524
5	1·0500	2·50	1·0036	0·480	—	—	—	0·9536
6	1·0476	3·00	0·9920	0·480	—	—	—	0·9444
7	1·0405	3·50	0·9840	0·420	—	—	—	0·9435
8	1·0294	4·00	0·9960	0·292	—	—	—	0·9666
9	1·0161	4·00	—	—	1·0161	0·985	0·075	0·969
10	1·0294	4·00	—	—	1·000	0·968	0·16	0·968
11	1·0405	4·00	—	—	1·000	0·948	0·26	0·948
12	1·0476	4·00	—	—	1·000	0·932	0·34	0·932
13	1·0500	4·00	—	—	1·000	0·932	0·34	0·932
14	1·0476	4·00	—	—	1·000	0·939	0·305	0·939
15	1·0405	4·00	—	—	1·000	—	—	—
16	1·0294	4·00	—	—	1·000	—	—	—
17	1·0161	4·00	—	—	1·000	—	—	—
18	1·0000	4·000	—	—	1·000	1·000	0·00	1·0

TABLE III. QUANTITIES REPRESENTING THE CONDITIONS IN DIFFUSER 2 AT INTERVALS OF ONE MILLISECOND

0	1·0000	0·00	1·000	0	—	—	—	1·00
1	1·0161	0·25	1·0128	0·096	—	—	—	0·997
2	1·0294	0·50	1·0224	0·181	—	—	—	0·993
3	1·0405	0·75	1·0267	0·275	—	—	—	0·986
4	1·0476	1·00	1·0258	0·348	—	—	—	0·978
5	1·0500	1·25	1·0214	0·390	—	—	—	0·971
6	1·0476	1·50	1·0174	0·390	—	—	—	0·970
7	1·0405	1·75	1·0138	0·338	—	—	—	0·973
8	1·0294	2·00	1·0100	0·244	—	—	—	0·981
9	1·0161	2·00	—	—	1·0161	0·987	0·235	0·971
10	1·0294	2·00	—	—	1·0000	0·963	—	0·963
11	1·0405	2·00	—	—	1·000	0·937	—	0·937
12	1·0476	2·00	—	—	1·000	0·933	—	0·933
13	1·0500	2·00	—	—	1·000	0·930	—	0·930
14	1·0476	2·00	—	—	1·000	0·933	—	0·933
15	1·0405	2·00	—	—	1·000	0·941	—	0·941
16	1·0294	2·00	—	—	1·000	0·950	—	0·950
17	1·0161	2·00	—	—	1·000	0·981	—	0·981
18	1·0000	2·00	—	—	1·000	1·000	0·1	1·000

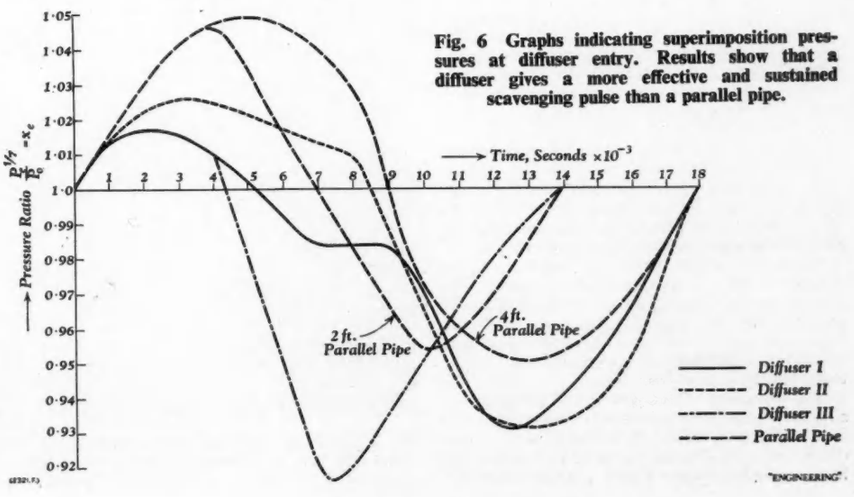

Fig. 6 Graphs indicating superimposition pressures at diffuser entry. Results show that a diffuser gives a more effective and sustained scavenging pulse than a parallel pipe.

TABLE IV. QUANTITIES REPRESENTING THE CONDITIONS IN DIFFUSER 3 AT INTERVALS OF ONE MILLISECOND

0	1·0000	0·00	1·000	0·0	—	—	—	1·00
1	1·0161	0·50	1·096	0·096	—	—	—	0·9967
2	1·0294	1·00	1·0176	0·204	—	—	—	0·9882
3	1·0405	1·50	1·0160	0·324	—	—	—	0·9755
4	1·0476	2·00	1·0100	0·424	—	—	—	0·9524
5	1·0161	2·00	—	—	1·050	0·979	0·615	0·929
6	1·0294	2·00	—	—	1·0476	0·946	0·750	0·8984
7	1·0405	2·00	—	—	1·0405	0·910	0·850	0·8695
8	1·0476	2·00	—	—	1·0294	0·926	0·670	0·8966
9	1·0500	2·00	—	—	1·0161	0·936	0·470	0·9194
10	1·0476	2·00	—	—	1·000	0·950	0·250	0·950
11	1·0405	2·00	—	—	1·000	0·959	0·205	0·959
12	1·0294	2·00	—	—	1·000	0·970	0·150	0·970
13	1·0161	2·00	—	—	1·000	0·992	0·040	0·992
14	1·0000	2·00	—	—	1·000	1·00	0·00	1·00

to lead to an improvement in efficiency, frictional effects again assume such proportions as to cancel, or even to outweigh the gain theoretically attainable by this means.

With reference to the shorter diffuser 3, the improvement over the simple case of a parallel pipe is considerably smaller than with diffusers 1 and 2. The duration of the returning rarefaction wave is considerably diminished, as might be expected.

THE EFFICIENCY OF A DIFFUSER

The efficiency of a diffuser may best be expressed quantitatively as the ratio

$$\frac{\text{Energy contents of fundamental pulse—energy rejected to atmosphere}}{\text{Energy contents of fundamental pulse}}$$

or

$$\frac{\Sigma u_1 \rho_1 \left[C_p (T_1 - T_0) + \frac{u_1^2}{2g}\right] \Delta t - \Sigma u_0 \rho_0 \frac{u_0^2}{2g} \Delta t}{\Sigma u_1 \rho_1 \left[C_p (T_1 - T_0) + \frac{u_1^2}{2g}\right] \Delta t},$$

where C_p is the specific heat at constant pressure and the suffixes $_1$ and $_0$ refer respectively to conditions of the fundamental pulse, and at the open end.

In Table V below this efficiency has been evaluated for the simple parallel pipe and the three diffusers described above.

TABLE V. *Efficiences of diffusers and parallel pipe*

—	Parallel Pipe	Diffusers		
		I	II	III
Efficiency (per cent.)	38·268	99·906	99·092	99·342

These figures are reflected in the corresponding values, given in Table V, of the time/amplitude integral of the reflected rarefaction wave, which is a measure of the scavenging efficiency.

TABLE VI. *Values of time/amplitude integral*

—	Parallel Pipe	Diffusers		
		I	II	III
$\Sigma\left[1 - \left(\frac{Pr}{P_0}\right)^{\frac{1}{3}}\right] \Delta t$	·003172	·0125856	·011145	·010351

SUMMARY OF CONCLUSIONS

From the examples given, certain general deductions may be made:

(i) A diffuser, whatever its dimensions and geometrical configuration, leads to the formation of a more effective scavenging pulse than may be obtained by the use of a plain parallel pipe.

(ii) Increased divergence of the diffuser tends at first to lead to improved efficiency, but the rate of improvement gradually diminishes with larger angles of divergence. Moreover, frictional effects play an increasingly important part and nullify any further improvement that might theoretically be possible.

(iii) The effect of changes in diffuser length is similar to that with increasing divergence. The improvement in efficiency is rapid at first, but diminishes with increasing length, until eventually frictional effects again nullify the gain theoretically possible by further lengthening the diffuser.

(iv) The choice of diffuser length is partly dictated by the need for correct timing of the scavenging pulse. A long diffuser tends to increase the duration of the scavenging pulse so that, in general, the higher the engine speed, the shorter the required diffuser length.

(v) In general, a short length of parallel pipe inserted between the exhaust ports (or valves) and the diffuser is beneficial in that it delays the arrival of the scavenging pulse until the pressure in the cylinder has fallen to the scavenging pressure.

(vi) Since the behaviour of the diffuser is governed by the parameter L/d as previously defined, it follows that for constant performance, the angle of divergence is approximately proportional to the diameter at the diffuser-entry.

BRUNSWICK WHARF POWER STATION

330-MW PLANT FIRED BY PULVERISED COAL WITH SUPPLEMENTARY OIL BURNERS

The Brunswick Wharf power station in the London Division of the British Electricity Authority, which was formally opened by Lord Citrine on Wednesday, October 6, is designed for an ultimate capacity of 330 MW. Its main equipment will consist of twelve pulverised-fuel fired boilers, each with an output of 320,000 lb. of steam per hour at a pressure of 900 lb. per square inch and a temperature of 900 deg. F., together with four 52·5-MW and two 60-MW generating sets. It began operation on March 26, 1952, and at present eight of the boilers and four 52·5-MW sets have been commissioned. John Bruce and Partners, George-street, London, W.1, are the consulting engineers, L. G. Mouchel and Partners, 36 Victoria-street, London, S.W.1, co-operating with them in the civil engineering work. The Divisional Controller is Mr. H. V. Pugh.

CIVIL ENGINEERING WORK

The station covers an area of about 19 acres on the north bank of the River Thames, near the portal of the Blackwall tunnel. It is interesting from the fact that it has been constructed in a disused dock, part of which is being used for the storage of coal. One-third of this coal stock is to be kept under water as a precaution against deterioration from overheating or spontaneous combustion.

A wharf, 850 ft. long, with a deep-water frontage to the river, has been constructed for unloading the seaborne coal. Rails have been laid to carry the coal cranes and there is also a road for vehicular traffic. The space between the new and old walls has been filled with mass concrete, thus enabling a 17-ft. strip of river frontage to be reclaimed. The river was dredged in front of the new wall and a chalk bed was deposited, so that colliers can be moored alongside at any state of the tide. The main contractors for this part of the work were Marples, Ridgeway and Partners, Limited, 2 Lygon-place, London, S.W.1.

The foundations of the power station building consist of spread bases laid on London blue clay, which was found 9 ft. below the bottom of the dock. The basement is a reinforced-concrete tank, the north and west sides of which incorporate the 66-in. outlet culverts for the circulating water. The south wall, which also forms the north wall of the coal store, is parabolic in plan and includes the foundations for one of the tracks of the coal transporter bridge. The other track of this bridge is carried on 60-ft. precast reinforced-concrete piles. All-round access to the site is provided by a suspended roadway on the south side from which the brick-clad reinforced-concrete ash and dust bunkers rise.

The main and subsidiary buildings are of steel-frame construction with brick cladding. Two expansion joints have been incorporated in the main building owing to its length; and divide it into three separate sections. The walls of the

Fig. 1 View of the Brunswick Wharf power station, London, from the north-west. This station, which will have an ultimate installed capacity of 330 MW, is built in a disused dock on the north bank of the Thames.

132-kV switch house are of 15½-in. cavity construction with double glazing to reduce the heat losses in cold weather. The main building contractors were Peter Lind and Company, Limited, London, the structural steelwork being supplied by Redpath Brown and Company, Limited, Edinburgh 7. An exterior view of the station from the north-west is given in Fig. 1.

COAL SUPPLIES

Coal for consumption in the station will be unloaded from sea-going colliers by four high-speed level-luffing cranes, three of which are at present installed. Each of these cranes, which were manufactured by Stothert and Pitt, Limited, Bath, have a capacity of 200 tons per hour and feed a common conveyor belt, supplied by International Combustion, Limited, Woburn-place, London, W.C.1. This conveyor, the capacity of which is 800 tons per hour, passes through a junction house, where the coal is reduced in crushers before being sent forward either to the boiler house bunker or to the storage ground. This ground is spanned by a travelling bridge with a conveyor on its lower chord for the discharge of the coal; and a second conveyor on its upper chord for reclamation. It is served by two cranes, each with a capacity of 100 tons per hour. The travelling bridge was manufactured by Fraser and Chalmers, Limited, Erith, and the associated cranes by Stothert and Pitt, Limited.

STEAM RAISING PLANT

Each of the 12 pulverised-fuel-fired steam-raising units, of which eight have now been commissioned, is designed for an output of 320,000 lb. of steam per hour at a pressure of 925 lb. per square inch and a temperature of 925 deg. F., when supplied with feed water at 365 deg. F. Each boiler has a heating surface of 8,200 sq. ft.; the heating surface of the combustion chamber walls being 5,950 sq. ft. The manufacturers of ten of the boiler units are Clarke, Chapman and Company, Limited, Gateshead-on-Tyne, while the other two are being supplied by John Brown and Company (Clydebank), Limited, Sheffield, to the former firm's design. In all cases the combustion chambers and combustion equipment were manufactured by International Combustion, Limited, while the superheaters were supplied by the Superheater Company, Limited, 53 Haymarket, London, S.W.1, the economisers by Senior Economisers, Limited, 11 Southampton-row, London, W.C.1, and the air heaters and fans by James Howden and Company (Land), Limited, Scotland-street, Glasgow, C.5.

The individual boilers are fired from three bowl-and-roller pulverisers, each of which is driven by Laurence Scott and Electromotors Trislot motors and has an output of 20,000 lb. per hour when dealing with coal with an initial moisture content of 10 per cent. This coal is delivered to 12 tangential burners, which are arranged in groups of three at each corner of the 24,063 cub. ft. combustion chamber. Oil burners are also provided in the pulveriser fuel burner assemblies for use when starting up and to maintain ignition at low loads, when burning poor quality coal. Fully automatic control is provided by apparatus manufactured by Bailey Meters and Controls, Limited, Progress-way, Purley-way, Croydon.

The flue gases are discharged into two 300-ft. reinforced concrete chimneys, which are lined with Norri acid-resisting bricks and are mounted on a steel pedestal faced with Southwater and Blockley bricks in which Howden grit arresters and electrostatic precipitator plant are installed. This precipitator plant was supplied by the Sturtevant Engineering Company, Limited, Cannon-street, London, E.C.4.

The boiler ash, as well as the dust from the economisers, air heaters and the electrostatic precipitators, is handled by plant installed by Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, and is delivered to bins at each end of the boiler house. It is then discharged to road vehicles or to barges by a conveyor system provided by International Combustion, Limited. When, owing to fog or for other reasons, it cannot be taken away it can be dumped near the disused river entrance lock which has been dammed at both ends and filled with rubble and hard core.

GENERATING UNITS

The generating plant which, as has already been stated, will eventually consist of four 52·5-MW and two 60-MW turbo-alternators units of which the four 52·5-MW units have now been commissioned. These sets were manufactured by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester 17, and consist of a three-cylinder turbine, which is directly coupled to a 61·765-MVA totally-enclosed, fan-cooled direct-excited alternator. There are 11 impulse stages in the high pressure cylinder of the turbine, 14 in the intermediate pressure cylinder and four in each half of the double flow low pressure cylinder, the fourth expansion in each half being effected in two sets of nozzles and two impulse wheels. The existing plant is illustrated in Fig. 2.

The turbines of the 60-MW sets will also be of the three-cylinder type and will be direct-coupled to 75-MVA alternators, which will, however, be hydrogen-cooled.

CIRCULATING WATER SYSTEM

The low pressure cylinders of the 52·5-MW sets exhaust into twin condensers of Metropolitan-Vickers manufacture, the total cooling surface of which is 48,000 sq. ft. These condensers are cooled by river water, which is drawn in through an intake on the jetty. This intake consists of screen chambers, suction chambers and pump pits and its walls, which are of reinforced concrete, 4 ft. thick, were built inside a sheet pile cofferdam with steel whalings and bracings. The pressure exerted at the back of this dam at low tide was partly compensated by diagonal struts, which transmitted the load to material deposited against the piling on the river face, and partly by ties anchored back to other steel piles. This portion of the work was also carried out by Marples, Ridgeway and Partners, Limited.

The circulating water first passes through trash racks and then into the chambers, in which a total of ten Brackett screens are installed. It next flows into one of two suction chambers, whence it is withdrawn by the circulating pumps. These pumps, of which eight are already installed, are of Mather and Platt manufacture. They are of the vertical spindle type and are driven by 390-h.p. 3·3-kV Metropolitan-Vickers motors. The output of each unit is 32,000 gallons per minute, which is delivered to the condensers through 66-in. cast-iron pipes.

On leaving the condensers the circulating water returns to the river through two reinforced-concrete culverts, each of which is 6 ft. wide and 7 ft. 6 in. high, and at the mouths of which are four electrically operated penstocks, so that they can be isolated when necessary. The discharge works are situated at the downstream end of the wharf and include a 2-ft. thick apron, 50 ft. wide, which extends 50 ft. into the river so that full supplies will be available at low tide.

FEED HEATING ARRANGEMENTS

The condensate from each set is extracted by two pumps, each of which has a capacity of 790 gallons per minute. It then passes through three stages of low pressure heaters to the feed pumps. These pumps, of which there are two for each set, were manufactured by Mather and Platt, Limited, Newton Heath, Manchester 10. They are electrically driven and have an output of 500,000 lb. per hour. In addition, a steam-driven pump is provided for each group of three turbines. De-aeration is effected at the third feed heating stage. The condensate is finally delivered to the boilers through two high-pressure heaters, the temperature being 365 deg. F. in the case of the 52·5-MW sets and 380 deg. F. for the 60-MW sets. All this feed-heating plant is of Metropolitan-Vickers manufacture.

The central evaporating plant, which has been installed by Aiton and Company, Limited, Derby, is designed for operation by live steam and has an output of 80,000 lb. of distillate per hour. This distillate has a dissolved oxygen content not exceeding 0·025 cub. cm. per litre, a total solid content not exceeding 0·5 parts per 100,000 and a pH value of 8·5.

To be continued

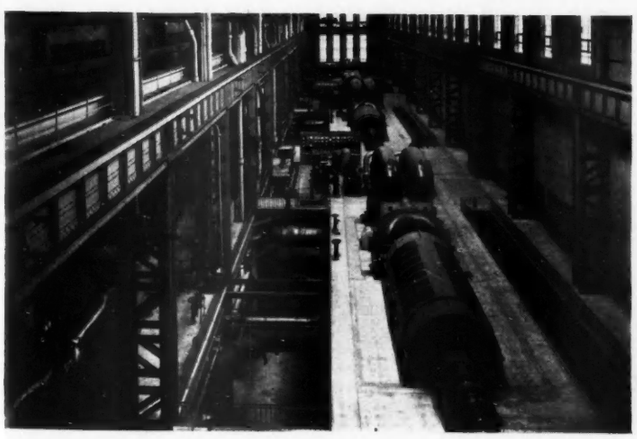

Fig. 2 Three of the four 52·5-MW turbo-alternators which are already in service.

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JUBILEE OF THE THERMIONIC VALVE

Arrangements for Celebration

The jubilee of the invention of the thermionic valve by Sir Ambrose Fleming will be marked by the unveiling of a plaque at University College, London, on Tuesday, November 16, the ceremony being performed by the Lord President of the Council, the Marquess of Salisbury, K.G.

A conversazione will also be held in the electrical engineering department of the college on Tuesday, November 16, and the two following days, at which exhibits and documents relating to Fleming's work will be shown. Examples of recent radio research will also be on view. Admission to this conversazione will be by invitation only; and we are asked to state that a limited number of tickets, available between 3 p.m. and 10 p.m. on Wednesday, November 17, can be obtained by senior engineers or members of the radio industry on application to the Assistant Secretary, University College, Gower-street, London, W.C.1.

As already announced, the jubilee of Fleming's invention will also be celebrated at a meeting at the Institution of Electrical Engineers on Tuesday, November 16, when the Lord President of the Council will give an address and lectures will be delivered by Professor G. W. O. Howe, Sir Edward Appleton and Dr. J. Thomson.

Fig. 1 A universal dual-voltage ground power unit which provides 112-volt and 28-volt supplies for starting and operating the electrical services on all types of present-day aircraft.

Fig. 2 Hydraulically-operated mobile maintenance steps designed to provide a working platform, adjustable for height, which can overhang the top of the fuselage, wings, or tailplane.

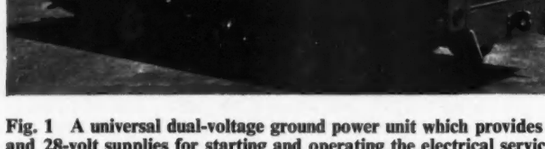


Fig. 3 The Safety Raiser—a mobile hydraulically-operated maintenance platform which is adjustable for height.

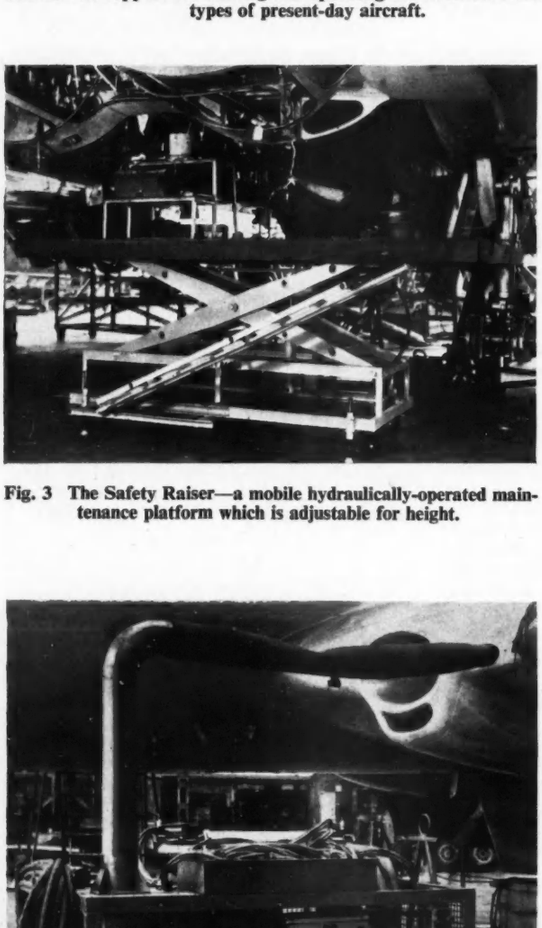


Fig. 4 Alternator test set designed for testing the alternator circuits on the Comet airliner, thus avoiding extensive engine running on the ground.

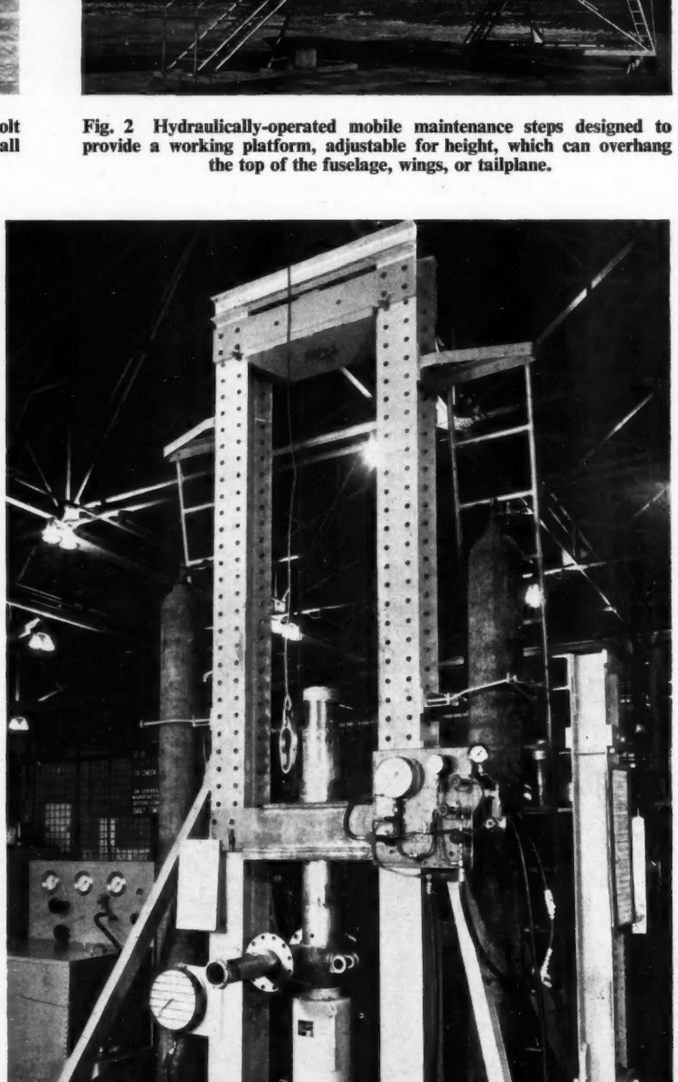


Fig. 5 Test rig used in the overhaul workshops for dismantling, testing and functional checking of aircraft oleo legs. It is capable of applying a maximum load of 50 tons.

MAINTENANCE PLANNING IN B.O.A.C.

PLANT AND METHODS FOR CURRENT AND FUTURE AIRCRAFT

This article is concerned primarily with the planning of maintenance and inspection of British Overseas Airways Corporation's aircraft fleets, for which there are at present four base servicing organisations co-ordinated from a central department. Three of these are at London Airport—for the Argonaut and York fleets, the Hermes fleet (operating temporarily due to withdrawal of Comets) and the basic organisation for the future Britannia fleet. The maintenance organisation for the Stratocruiser and Constellation fleets is at present based at Filton, but is steadily being transferred to London Airport as construction of the new headquarters building becomes sufficiently advanced.

The engineering organisation of an airline covering a world network of routes is necessarily complex. So far as possible all B.O.A.C.'s maintenance work, other than essential en-route servicing, is carried out at the home bases in the United Kingdom, and is under the central technical direction of the Deputy Operations Director (Engineering Group). For administrative convenience, overseas maintenance is controlled by the Chief Stations Engineer, who maintains close liaison with the Chief Maintenance Engineer to whom he is functionally responsible. The engine and propeller repair factory at Treforest is, similarly, under independent direction but in close contact with the Chief Maintenance Engineer, who has direct control over the maintenance of the aircraft fleets, the component repair and overhaul shops, and the radio maintenance shop, all of which are located at London Airport.

The day-to-day organisation of aircraft maintenance has to be correlated with the operating demands on the routes which each fleet serves. The four Fleet Maintenance Engineers are technically under the control of the Chief Maintenance Engineer, and produce serviceable aircraft to meet the schedules and frequencies required by the commercial and operations department.

Directly responsible to the Deputy Operation Director (Engineering) is the Chief Planning Engineer, who establishes the principles and policies of fleet maintenance throughout the Corporation, and with whose work this article is mainly concerned.

INSPECTION AND OVERHAUL REQUIREMENTS

There are several aspects of airline maintenance work: routine inspection, rectification of defects, and such overhaul as is required to keep the aircraft serviceable, together with the comprehensive inspection demanded periodically by the Air Registration Board for renewal of the Certificate of Airworthiness. As in most airlines to-day, British Overseas Airways Corporation carry out their routine inspections on a basis of the number of flying hours completed, in four graded "checks." "Lives" are assigned to as many components as possible; when their life has "expired" they are removed for inspection and overhaul, and replaced by overhauled components. Overhaul and repair of components is not carried out in the fleet hangars but in repair shops which serve all the fleets.

Inspection of any parts of the aircraft which are not "lifed," or which are not inspected as a matter of course during the routine checks, is distributed over the major overhaul checks so as to ensure that the entire aircraft has been inspected within a two-year period. It is the function of the Chief Planning Engineer's department to work out the schedules and distribute the work over the check periods in such a way as to obtain the optimum utilisation of aircraft and manpower, and to ensure that the necessary personnel and equipment are available when required.

PLANNING FOR FUTURE AIRCRAFT FLEETS

The work of the planning branch falls into three sections—project, methods, and control. The project planning section covers the maintenance facilities for future aircraft fleets, and goes into action in the early stages of the production of aircraft intended for operation by the Corporation. This section collaborates with the specialised branches concerned in establishing the necessary spares, tools and equipment for maintenance, workshops, overseas bases, and engine overhaul.

Aircraft maintenance and overhaul equipment falls roughly into two classes: that which is universally suitable for various aircraft, and that which is "peculiar to type"—the latter being constructed specifically for one aircraft type and one operation.

It is always the object to produce as much as possible of the fleet ground equipment in such a manner that the design does not unduly restrict its use on other types. This has been achieved in the case of the universal ground-power unit (Fig. 1), which provides a dual-voltage electrical supply (112 volts and 28 volts) for starting and operating electrical services on all current B.O.A.C. aircraft. This unit, supplied by Auto Diesels, Limited, and powered by an 11·1-litre Leyland Diesel engine, was described on page 780 of our 175th volume (June 19, 1953).

Other equipment in the "universal" category is illustrated in Figs. 2 and 3. The hydraulically-operated mobile maintenance steps are designed to provide a working platform adjustable for height, which also overhangs the top of fuselage, wings or tail plane. The height range is from 14 ft. to 24 ft. and from 4 ft. 6 in. to 12 ft.

Mounted on a strong base there is, in the high steps, a fixed section, to the top of which is pivoted a length of adjustable steps terminating at the working platform. By means of a manually operated hydraulic jack the platform can be located at any height within its range and safely locked in position by a locking pin, controlled by a lever adjacent to the hydraulic pump. Retractable chassis jacks are fitted to hold the steps stationary and to prevent rocking. In addition, the high steps have four sockets fitted to the platform to which can be fitted a jib—as shown in the illustration—which is used for removing or installing fins, rudders, etc.

In Fig. 3 is illustrated the Safety Raiser, constructed to the Corporation's specification by Access Equipment Limited, Braemar-avenue, Neasden, London, N.W.10. The Safety Raiser is a mobile hydraulically-operated maintenance platform produced in two sizes, with height ranges respectively of 2 ft. 6 in. to 7 ft. 6 in. and 5 ft. to 10 ft. The machines have a very large working platform—either 10 ft. by 6 ft. or 10 ft. by 4 ft. 6 in. The illustration shows the smaller type with the large platform in position under two engine nacelles of a Comet aircraft. The hydraulic pump is fitted below the platform so that the machine can be operated from the platform to any desired height, a mechanical lock holding it in any set position. Screw-type floor steadies are fitted to the chassis to prevent movement or rocking of the platform when in use.

Where such flexibility of application cannot be achieved, it is still desirable to specify equipment which can be converted without major structural change, provided that the original usefulness does not suffer or the unit become uneconomical in consequence.

Nevertheless, modern aircraft still require a certain amount of specialised equipment which must be produced specifically for a single purpose. The alternator test rig illustrated in Fig. 4 is a typical example, where the test required is of a pattern that is not repeated on any other aircraft.

MOBILE ALTERNATOR TEST RIG

This test rig was specifically designed by B.O.A.C. for testing Comet aircraft alternator circuits, thus avoiding extensive ground engine running. It comprises two aircraft alternators, multiple-belt-driven by a 30-h.p. electric motor. A 20-in. fan driven by a 5-h.p. motor provides the necessary cooling air, a smaller fan with a 1-h.p. electric motor providing cooling air for the two alternators fitted to the test rig. This allows the following components in the alternator circuits to be tested in situ, while the aircraft is undergoing normal routine maintenance: the main rectifiers, hold-in transformers, hold-in rectifiers, main voltage regulators, pilot voltage regulators, stabilising transformers, equalising resistance, equalising system, ammeters, wiring and connections.

An example of a non-mobile piece of equipment designed by B.O.A.C. and used in their workshops for dismantling, testing and functional checking of aircraft oleo legs is shown in Fig. 5. In this rig, two air bottles supply high-pressure air to the legs, through a reducing valve, and a hydraulic jack at the bottom of the rig is used for loading the legs. This jack is capable of applying a maximum load of 50 tons.

The project-planning section also assess the staff and the training required for home bases and overseas stations, and ensure that the necessary accommodation—hangars, run-up areas, stores, overhaul workshops and offices—is available and suitably equipped. A maintenance survey team, composed of practical maintenance engineers from the fleet organisation, and planning engineers from the methods section, is attached to the manufacturer to study the aircraft in detail to determine the best maintenance procedure.

SPARES

The provisioning of aircraft spares is related to the anticipated overhaul life, the defect rate, and the elapsed time required for overhaul. These factors are agreed by consultation between the planning department, the supplies branch, and the fleet and workshop engineering organisations. The requirements for special plant and equipment are decided by the plant and equipment section in conjunction with fleet engineering and planning representatives. The detail design of the aircraft is unsettled and liable to modification at quite a late stage in production and the maintenance survey team must therefore keep a look-out for such changes and assess the effect upon equipment and spares provisioning.

In the first stage the planning is concerned with the requirements for the first few aircraft of the new fleet, this forming the basis of the complete inspection and maintenance procedure, including overseas, for the whole fleet. In the second phase, which deals with the major routines and overhauls, bulk supplies, etc., a fleet unit comprising flying crew, maintenance engineers, planning, technical, inspection, and supplies staff, is formed. Thereafter, the project planning section hands over the work of maintenance planning in stages to the current methods and control sections. In conjunction with the methods planning section the essential data are obtained for working out maintenance and overhaul methods, and compiling provisional schedules. The progress of the work is reviewed at monthly meetings held by the Chief Planning Engineer.

In addition to planning for the immediate future the project section is concerned also with long-term planning for possible future fleets. At present, for instance, B.O.A.C. are studying engineering maintenance aspects and problems on the latest military types in preparation for civil developments along the same lines.

WORK PLANNING AND AIRCRAFT SCHEDULING

The methods planning section works in close liaison with the control planning section, and is

responsible for establishing the best methods and systems to be employed in maintenance and overhaul work. The control section, in collaboration with the operations department, ensures that the aircraft are scheduled in such a way that the maintenance programme can be most efficiently carried out. This is achieved by arranging the aircraft to be brought into base in a sequence which will ensure an even flow of work both to the maintenance staff and the repair shops, while operating at the maximum possible aircraft utilisation. Planning engineers are assigned to each fleet maintenance organisation and to the repair shops.

FLYING-HOUR PERIODS

At this stage it is desirable to state briefly what each check entails. The actual period or flying hours between checks varies with the type of aircraft. As an example, in the case of the Argonaut the approved check cycle is: check 1, every 100 flying hours; check 2, every 200 flying hours; check 3, every 360 flying hours; check 4, every 1,400 flying hours. The check 1 consists broadly in opening up all panels which give access to parts requiring frequent inspection, and functionally checking all essential mechanisms. Checks 2 and 3 are basically similar to check 1 but embrace a larger range of items for test and inspection in keeping with the greater flying hours approved between checks.

When a check 4 falls due, the aircraft is opened up for careful inspection of the structure, and operational checking of all systems. At this stage a portion of the overhaul work required for the renewal of the Certificate of Airworthiness is carried out, and outstanding major modifications are incorporated. As many as possible of the lifed components are changed during check 4 to avoid interference and delay during minor checks.

On the Britannia the initial check cycle will probably be in the order of: check 1, every 60 flying hours; check 2, every 120 flying hours; check 3, every 325 flying hours; and check 4, every 925 flying hours. After several years' experience in the operation of these aircraft, and subject to satisfactory performance of the airframe and engines, it is hoped that the check cycle will have developed to figures approximating the following: check 1, every 85 flying hours; check 2, every 165 flying hours; check 3, every 400 flying hours; check 4, every 1,500 flying hours.

COMPONENT LIFE HOURS

Component lives are allotted in consultation with the chief inspector, the manufacturers, and the Air Registration Board, and so far as possible these are arranged to be the same as, or a multiple of, the period between check 4 inspections. The latter are in turn related to the proposed annual utilisation (i.e., flying hours per year) for the aircraft. When the Air Registration Board has finally approved the lives and check periods, they have a statutory value and can only be changed with the Air Registration Board's permission.

As experience is gained with a new aircraft the annual utilisation will probably be progressively increased. Concurrently, it is desirable to step up the component lives. In anticipation of increased work for the aircraft, by agreement with the Air Registration Board, several components of a particular type are run over a longer period and reports are submitted on their condition when stripped. If satisfactory, the longer life is granted approval. It is not always possible, however, to increase the life of components which have high defect rates, or increase the hours between checks to match the greater aircraft utilisation, and in this case it may be more efficient to accept the greater utilisation without increasing the check 4 period. This would mean in effect carrying out more than the desirable four check 4 inspections during the two-year periods. This necessitates the reorganisation and intensification of maintenance work to avoid taking on extra manpower, which can generally be achieved without difficulty since by that time a good background of maintenance experience has been acquired.

DETAILED BREAKDOWN OF AIRCRAFT SYSTEMS

Returning to the planning of a complete maintenance system for a new aircraft, within the last three or four years B.O.A.C. have developed a more detailed method of planning maintenance and overhaul work which, in the first place, was applied to the Argonaut fleet, and is now being worked out in a more highly developed form for the future Britannia. As applied to the Britannia every part of the aircraft, which is being broken down into systems, is listed in a maintenance planning schedule, and is assigned a reference number. In this schedule is also entered the type of work which will be involved on each routine check.

From the maintenance planning schedule, the work study schedule is derived. Methods are worked out and detailed estimates are prepared of the time required to carry out each job, and the spares and equipment necessary. The number of men of various trades and grades is assessed. These estimates will be compared as soon as possible with an actual performance of the work, and any necessary revisions will be made. An abridged schedule will be issued to the fleet.

In conjunction with the maintenance planning schedule the statutory maintenance inspection schedule is also produced, which, after acceptance by the Air Registration Board, cannot be amended without further approval. The corporation and the Air Registration Board are now developing a pictorial type of schedule for submission as the master document.

It has already been mentioned that some parts of the aircraft require inspection or overhaul only at multiples of the check 4 period. From the work-study sheet, which gives the number of men and the total time required to carry out the work, it is possible to spread these various items over the first, second, third, and fourth check 4 inspections, so as to ensure that, at each inspection, the time spent by the aircraft on the ground and the number of man-hours absorbed are kept constant and to the minimum. Cases occur, especially in the early life of a fleet, in which it is not possible or economic to arrange for all component lives to match up with the check 4 periods. Whenever possible, however, such anomalies are avoided. The work can be readily arranged to include the structural inspections required for the Certificate of Airworthiness, as well as providing a practical grouping of the components requiring overhaul, thus avoiding uneven loading on the repair shops and minimising the spares held.

The engineering planning section aims to establish what work is to be done, when it should be done, how it will be done, how long it should take, and what it will cost. The plan represents the most efficient use of the aeroplane, manpower, materials and equipment. There may be times when the task cannot precisely follow the set pattern, but the plan is an instrument that enables management readily to study results against forecasts, the cause and effect of deviations, judge performance, analyse systems and methods, in order to improve efficiency.

ESCAPING FROM SUBMARINES

THE ROYAL NAVY DEVELOPS A NEW TECHNIQUE

Rather more than 50 years ago, in March, 1904, the Royal Navy suffered its first submarine disaster, when the submarine A1 was rammed by the steamer Berwick Castle and sank with all hands. Within the next ten years there were five more accidents, though only two of the six were the result of what may be termed submarine hazards; the other four were accidents which might have happened equally to surface vessels. During that period the official escape policy was to try to save the crew by raising the submarine, but in no case was it successful, so attention was directed to devising means to enable the crew to escape from the submarine while she lay on the bottom. The result was the introduction, first, of the cumbersome Hall Rees self-contained breathing set, soon discarded, and secondly, of the lighter and handier Davis escape apparatus, which is still standard equipment in many of H.M. submarines.

A constructional improvement was the introduction of bulkheads in submarines, the presence of which was instrumental in enabling the first successful escape to be made in 1916, when the submarines E4 and E41 collided and both sank. In this case, a stoker petty officer managed to open a hatch and rise to the surface (from a depth of 30 ft.) without the aid of any breathing apparatus.

The Davis submarine escape apparatus ("D.S.E.A.") became standard equipment in 1930 and proved its value in the following year when H.M.S. Poseidon was sunk by collision in Chinese waters, but the experience thus gained showed the need for some means to prevent the air from escaping too quickly from the submarine when the hatch was opened. It was decided, therefore, to provide special escape hatches, fitted with cylindrical trunks of stout twill extending down to within about 2 ft. of the floorplates, thus containing only a small volume of air beneath the hatch. By this means, men could stand with their heads in air while waiting their turn to enter the trunk, one by one, and open the hatch.

TRAINING IN TANKS

By 1933 it had been decided to abandon salvage as a possible means of saving the crew of a sunken submarine and to rely on the Davis apparatus. Concurrently, stronger bulkheads were fitted in new vessels, to make escape practicable from depths down to 200 ft., and two-man escape chambers, one at each end of the submarine, were to be fitted in lieu of the twill trunks; though in fact the twill trunks continued in use, as the loss of the Thetis in 1939 showed that the two-man escape chamber had certain disadvantages. Following the Thetis disaster, a committee was appointed to review the whole question of escape from submarines. This committee, under the chairmanship of Admiral Sir Martin Nasmith, recommended that the two-man escape chamber should be abandoned, that the twill trunk should be retained, and that a tank 100 ft. deep should be provided for escape training, to supplement the existing 30-ft. tank at Fort Blockhouse, the submarine establishment at Gosport.

An important move by the Nasmith Committee was to initiate physiological research into the problems of escaping from submarines. It was found, as a result, that the danger of CO_2 poisoning was much greater under pressure than had been supposed, and that, if men wore their Davis apparatus too long, there was an equal or, in some cases, a greater danger of oxygen poisoning; all of which pointed to the need to accelerate the process of escaping.

FREE ASCENT

After the second World War, the Admiralty appointed another committee, to review escape policy in the light of the very considerable experi-

Fig. 1 Submarine escape training is carried out in this tower which contains a tank 100 ft. deep.

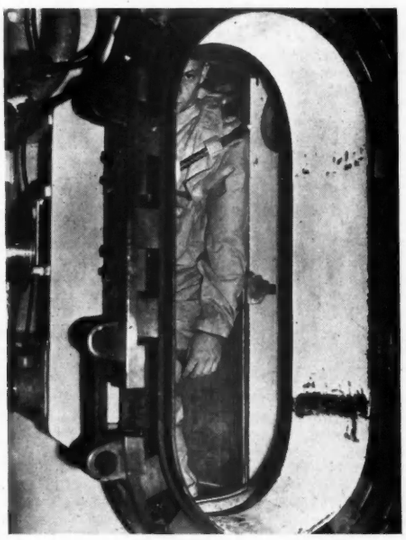


Fig. 2 One-man escape chamber situated below the tank.

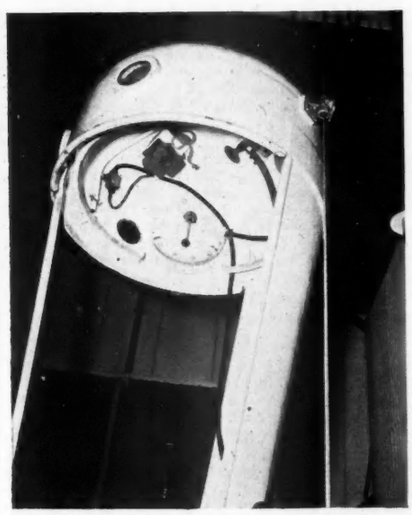


Fig. 3 The diving bell can be rapidly raised and lowered by a winch and carries two instructors.

ence gained during the war. This committee found that the main hazard was not the ascent from the submarine, but the period before escaping, especially while "flooding up" to equalise the pressure on the hatch covers. They also found that, during the war, as many men escaped by making free ascents without breathing apparatus as did so with the Davis gear. It was their recommendation, therefore, that the twill trunk should be abolished in favour of a one-man escape chamber and that "free ascent" should be the practice and the use of the Davis apparatus should be abandoned.

The training given in H.M.S. Dolphin, the submarine base at Fort Blockhouse, is now established on that basis and, since June of the present year, some 300 men have gone through the course. The tank, 18 ft. in. diameter and 100 ft. deep, is painted white inside and brilliantly illuminated through glass scuttles so that the trainee, and spectators at the top of the tank, can see exactly what is happening in the 100 ft. depth of water. The tank, which contains 700 tons of water, is built into the tower illustrated in Fig. 1. Beneath the tank is a one-man escape chamber (Fig. 2) and on the bottom of the tank is a replica of a submarine's conning tower, situated in the same position relative to the escape hatch as it would be in an actual submarine. At the 30-ft. and 60-ft. levels below the surface of the water are recesses in the side of the tank, in which the trainees can stand, with their heads in pockets of air, until the time for them to ascend. In addition, a diving bell in the form of an inverted open-ended hemisphere 4½ ft. in diameter with a platform 4½ ft. below it, which carries two instructors, can be lowered to any desired level so that the instructors can wait, also in pockets of air, until their services are required. They are in telephonic communication with the officer in charge, who stands on a platform at the top of the tank. The water is maintained at a temperature of 80 deg. F.

BELL AND ASSOCIATED EQUIPMENT

The bell, shown in Fig. 3, is suspended on two wire cables in order to ensure safety and maintain equilibrium, and these pass from anchorages on the bell, over head sheaves, to the divided drum of the winch. The transmission from the driving motor to the drum incorporates a totally-enclosed worm reduction unit, and alternative hand operation is provided in case of power failure. The main contractor responsible for the winch equipment concerned in raising and lowering the bell was M. B. Wild and Company, Limited, Argyle-street, Nechells, Birmingham 7, and the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, collaborated with them in the supply of all electrical equipment. This equipment comprises a 15-h.p. direct-current winch motor which is supplied from a motor-generator set, and the motor, motor-generator set and associated alternating-current and direct-current contactor cubicles are mounted on the winch platform.

Fitted to the diving bell is a drum controller operated by a handle inside the bell. A second controller, which affords alternative control by an observer outside the tank is located in a special control cabinet. The cabinet also houses a changeover switch which selects the control position, a depth selector, a pistol-grip switch for raising the bell above water level and an emergency stop button.

It is necessary for the hoist motor to respond very rapidly to any change in speed called for by the instructor and to attain the speed corresponding to the position of the controller as quickly as possible. Moreover, the speed must be unaffected by change in load as the bell ascends or descends. It must also be possible to bring the bell quickly to rest. To meet these requirements a closed-loop control system, embodying a five-field exciter, is used and in addition to speed of response, its advantages include simplicity in operation and maintenance, a high degree of sensitivity and complete stability.

United States practice favours the use of a special form of diving bell which can be secured over one of the torpedo hatches of the submarine; but the submarine must first be located, and even then the attachment of the bell is a difficult process. The Admiralty intend to try this device in the near future, and the salvage vessel Kingsalvor has been equipped for this purpose.

BUILT-IN BREATHING SYSTEM

Meanwhile, on the recommendation of the second Admiralty committee, submarines are being filled with a fixed breathing system known as B.I.B.S. (built-in breathing system), which will enable the crew of a submarine to inhale a mixture of oxygen and nitrogen while awaiting their turns to escape; this mixture is so proportioned as to avoid the dangers of poisoning by CO_2 and by pure oxygen. The bottles of compressed gas (40 per cent. oxygen and 60 per cent. nitrogen) are built into the submarine, a tube and mouthpiece being provided for each man at each end of the submarine. The men will breathe from this system during the process of "flooding-up" the compartment and will then make free ascents through hatches fitted with twill trunks.

In new submarines, the policy is to fit strong bulkheads, which will withstand the full diving pressure of the submarine, and to fit them to take the American type of rescue bell at each end. They will also be fitted with air supply and exhaust connections at each end so that the air in the submarine can be changed while the rescue bell is on its way and is being fitted, and with a one-man escape chamber at each end, from which men can make free ascents. Immersion suits will be carried to lessen the risk of death by exposure when the men have reached the surface, and also radio indicator buoys, underwater telephones, and underwater signal ejectors for firing smoke candles from both ends of the submarine.

It has been decided that the provision of rescue-bell fittings on existing submarines is not justified. In these, therefore, twill trunks will continue to be employed, but using more rapid flooding valves. The built-in breathing system will also be used, in conjunction with immersion suits, in place of the Davis apparatus. It was emphasised, however, by Rear-Admiral G. B. H. Fawkes, C.B., C.V.O., C.B.E., the Flag Officer (Submarines) and by his Chief Staff Officer, Captain A. R. Hezlet, D.S.O., R.N., that "the best escape policy is still good drill, good maintenance and attention to sound submarine practice," so that accidents do not happen.

★ ★ ★

GOVERNMENT RESEARCH

D.S.I.R. Plans for 1954-55

Details of current and projected research work being undertaken by their research stations during the year ending March 31, 1955, have been issued by the Department of Scientific and Industrial Research, Charles House, 5-11 Regent-street, London, S.W.1.

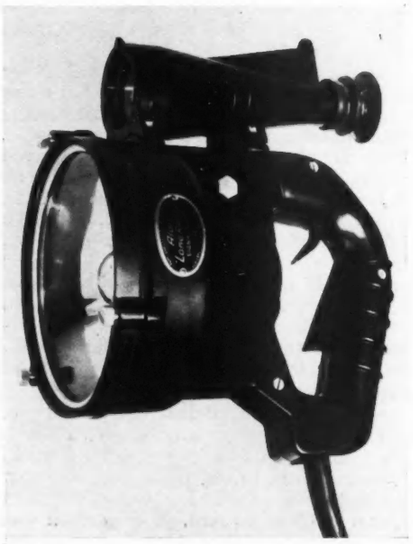
The information is classified according to Departments, and subdivided into the research sections in each Department. In some cases, notes are appended giving the stage to which each piece of work has progressed. Where research is being carried out for, or in conjunction with, a specific organisation, this is indicated.

ALDIS LONG-RANGE SIGNALLING LAMP

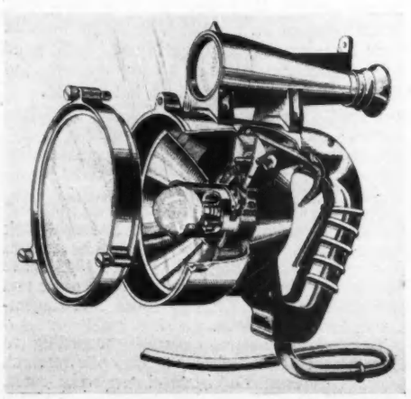
Improved Form Gives Longer Range and Better Signals

Although the Aldis signalling lamp has been in existence for nearly 40 years and has seen service in two world wars it has only quite recently been thought desirable to make any material alteration to the original design. As is well known, the main function of the lamp is to provide a simple, reliable and rapid method of signalling over visual distances.

On innumerable occasions, however, the Aldis lamp has been used in emergencies to provide a source of bright illumination for urgent repairs in close quarters and even for surgical operations; but it was designed for transmitting messages in Morse between ships at sea and between ships and the shore. The principal improvements in the new lamp are in the optical system, which gives a more powerful beam and thus a longer working range; and a new method of "chopping" the beam by means of a reciprocating cylindrical shutter which results in clearer and sharper signals with a higher speed of operation. Other improvements have been made which, it is claimed, have considerably increased the efficiency of the lamp in service. It is completely waterproof and fully protected against sea-water corrosion; and is equally suitable for use in tropical or Arctic climates.



The Aldis signalling lamp ready for use.



The body partly cut away to show the reciprocating cylindrical shutter. An improved optical system gives a longer working range.

The new lamp is shown in the accompanying illustrations. As will be seen, the body, which is an aluminium pressure die-casting, is partly cylindrical and partly conical, and is formed with a handle which incorporates a main switch and a trigger for signalling. The front of the body is closed by a plane glass disc mounted in a metal ring which is attached to the body by three screws, a watertight joint being made by a neoprene gasket. Mounted on top of the body is a waterproof sighting telescope giving a magnification of two diameters, and having a large-diameter objective which facilitates the use of the telescope in conditions of poor visibility and enables signals to be read from stations at or near the maximum range. The signalling beam has been given a divergence of over 6 deg. which enables it to be kept on a rapidly moving target without difficulty, even in a fairly rough sea.

The light source is a 60-watt 12-volt prefocused lamp with a single axial filament and is mounted horizontally at the focus of a paraboloidal mirror which is made of aluminium accurately formed, polished and anodised. The front end of the bulb is thickly silvered so that no light passes forward, the light being all directed backwards on to the mirror which reflects it forward in a beam which is slightly divergent for the reason previously explained. Signalling is effected by a thin reciprocating cylinder of aluminium alloy open at the front end and normally surrounding the rear part of the bulb so as to cut off the light from the mirror. Pressure on the signalling trigger draws the cylinder back and permits light to reach the mirror, the cylinder being returned to its forward position by a spring when the trigger is released. By suitably manipulating the trigger, short and long flashes can be sent out in the beam to form the letters of the Morse code, and thus a message can be transmitted. The reciprocating cylinder is very light and can be moved rapidly for long periods without fatigue; three dots per second can be sent which corresponds to twelve words per minute. The cylinder is anodised black to prevent internal reflections. It should be emphasised that the bulb burns at full brilliancy the whole time that signalling is in progress, the circuit being maintained by keeping the main switch in the handle depressed. When this switch is released the circuit is broken. It is pointed out that since the whole of the light from the bulb is used for transmitting the dots and dashes of the code and is completely cut off for the spaces between them the signals are clear and sharp and easy to read. The weight to be supported by the signaller is only about 4¾ lb.

To reduce the strength of the beam and so avoid dazzle at short ranges, and also to ensure secrecy when signalling at night, a "secret" device is provided, consisting of neutral filters and a metal plate with light-restricting apertures; it is fitted to the front of the body by three bayonet lugs. Red and green glass filters, secured in the same way, are also provided. Current for the lamp is normally supplied by a lead-acid battery rated at 12 volts and 15 ampere hours at a 20-hour discharge rate. The battery is of the non-spillable type. Connection to the lamp is made by a length of tough-rubber sheathed flexible cable, a two-pin socket being fitted on the battery box for the attachment of the cable. If desired, however, current can be taken from the mains, using a suitable resistance or transformer.

We recently witnessed an effective demonstration of signalling in full midday sunlight between Shell-Mex House, in the Strand, and the Monument, a distance of about 1½ miles. Signals were exchanged between these stations and the Wellington, the Headquarters ship of the Honourable Company of Master Mariners moored in the Thames off Temple Pier. The lamp is manufactured by Aldis Brothers, Limited, Birmingham, and the sole concessionnaires for sales in the United Kingdom are Kelvin and Hughes (Marine), Limited, 99 Fenchurch-street, London, E.C.3.

* * *

LAUNCHES AND TRIAL TRIPS

M.S. "TANK MONARCH."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for Sigurd Herlofson & Co. A/S, Oslo, Norway. Main dimensions: 649 ft. 8 in. overall by 80 ft. 6 in. by 44 ft. 9 in.; deadweight capacity, 28,800 tons; draught, 33 ft. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 8,200 b.h.p. at 112 r.p.m. Speed, about 14½ knots. Launch, September 21.

M.S. "NORTH CORNWALL."—Single-screw cargo vessel, built by Bartram & Sons, Ltd., Sunderland, for the North Shipping Co., Ltd. (Managers: Hugh Roberts & Son), Newcastle-upon-Tyne. Main dimensions: 425 ft. between perpendiculars by 58 ft. 9 in. by 38 ft. to shelter deck; deadweight capacity, 9,900 tons on a draught of 26 ft. 1 in. N.E.M.-Doxford four-cylinder opposed-piston oil engine, developing 3,300 b.h.p. at 109 r.p.m. in service. Speed on trial, 13·645 knots. Trial trip, September 21.

M.S. "POLYCLIPPER."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Einar Rasmussen, Kristiansand, Norway. Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, about 18,000 tons on a draught of 30 ft. 5 in.; oil-tank capacity, about 860,000 cub. ft. B. and W. nine-cylinder single-acting two-stroke Diesel engine, developing 9,000 i.h.p. Speed, 15¼ knots, fully loaded. Launch, September 23.

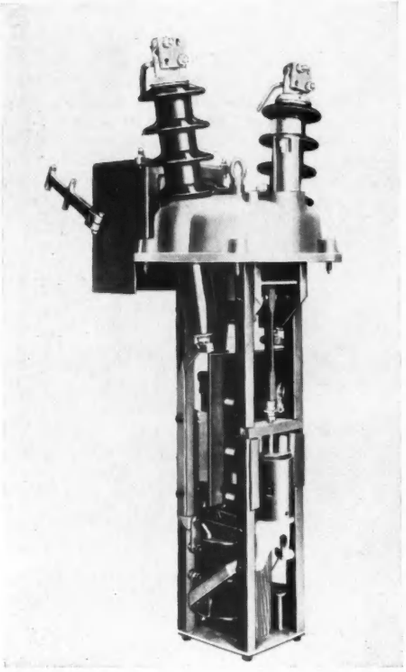
M.S. "TUGELA."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Wilh. Wilhelmsen, Oslo, Norway. Main dimensions: 470 ft. between perpendiculars by 65 ft. by 43 ft. to shelter deck; deadweight capacity, 10,350 tons on a draught of 27 ft. 7¼ in. B. and W. eight-cylinder single-acting two-stroke oil engine, developing about 10,000 b.h.p. Speed, 18 knots, fully loaded. Delivered, September 25.

M.S. "VESTVARD."—Single-screw oil tanker, built by Smith's Dock Co., Ltd., South Bank-on-Tees, for Klosters Rederi A/S (Manager: Lauritz Kloster), Oslo, Norway. Main dimensions: 555 ft. 9 in. overall by 71 ft. by 39 ft.; deadweight capacity, about 17,900 tons on a draught of 29 ft. 6 in. Kincaid-Harland and Wolff-Burmeister and Wain seven-cylinder single-acting opposed-piston oil engine, developing 7,600 b.h.p. at 110 r.p.m. in service, constructed by John G. Kincaid & Co., Ltd., Greenock. Service speed, 14¼ knots. Launch, September 27.

M.S. "CAPETAN CARRAS."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Tramp Chartering Corporation, Panama. Main dimensions: 450 ft. between perpendiculars by 62 ft. by 40 ft. 4 in. to shelter deck. Swan Hunter-Doxford five-cylinder opposed-piston oil engine, developing 5,500 b.h.p. at 115 r.p.m. in service. Launch, September 28.

M.S. "BELFAST."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for Belships Co., Ltd., Skibs A/S, Oslo, Norway. Main dimensions: 540 ft. between perpendiculars by 73 ft. by 39 ft. 3 in.; deadweight capacity, about 18,500 tons. Harland-B. and W. six-cylinder single-acting two-stroke oil engine. Launch, September 28.

M.S. "CEDARBANK."—Single-screw cargo vessel, built and engined by Harland and Wolff, Ltd., Belfast, for the Andrew Weir Shipping and Trading Co., Ltd., London, E.C.3. Main dimensions: 425 ft. between perpendiculars by 59 ft. by 38 ft. 3 in. to shelter deck; gross tonnage, about 5,800. Harland B. and W. six-cylinder single-acting two-stroke Diesel engine. Launch, September 29.



Automatic circuit re-closer for improving the continuity of supply on 11-kV rural lines.

AUTOMATIC CIRCUIT RE-CLOSER

Maintaining Continuity on Rural Lines

The accompanying illustration shows a piece of apparatus which should play a useful part in improving the continuity of electricity supply over rural lines. It has been jointly developed by the engineers of the Midlands Electricity Board and at the Willesden works of the British Thomson-Houston Company, Limited. It is designed to prevent transient faults from causing an interruption to the supply by first opening instantaneously and then re-closing automatically. It thus clears the fault before the associated fuse can blow and then restores the supply. As 80 per cent. of the faults on overhead lines are temporary they are cleared by de-energising the lines.

The "re-closer" is a single-pole dead tank oil circuit-breaker, which is normally held closed by springs and which incorporates a solenoid. The coil of this solenoid is connected in series with the line and when a fault current of at least twice its rating passes through it the plunger is pulled down and the circuit opened. The plunger is then returned to its original position by the springs.

The standard unit, which is intended for use on single- or three-phase rural lines up to 11 kV, is arranged to perform four consecutive opening operations and then to lock open. The first two of these openings occur instantaneously, while the other two have an inverse time characteristic. The trips of the inverse time delay deal with persistent faults, thus causing the protective fuses to blow and isolate the faulty section, a supply being maintained to the rest of the system in the meantime. Should a fault persist between the re-closer and the first fuse on the load side locking out will occur after the second trip. The re-closer must then be reclosed by hand.

The re-closer is designed for pole mounting and for current coil ratings of 5, 10, 15, 30, 50 and 100 amperes, all of which employ a common housing. Tapped coils are provided so that two ratings can be obtained by reconnecting a link in the coil circuit. The maximum breaking capacity in symmetrical amperes varies from 270 amperes in the smallest to 2,620 amperes in the two largest sizes.

* * *

ELECTRICITY SUPPLY AT REMOTE SITES

Double-Engine Automatic Generator Unit

When very high frequency radio is used for long-distance communication over deserts or across other isolated areas, an important consideration is the provision of a power supply at the intermediate repeater stations. These stations have to be erected at comparatively short distances apart on sites the positions of which are determined by optical considerations. It is therefore not always possible for them to be placed where a public electricity supply is available so some form of engine-driven equipment must be installed. It is also essential that this equipment shall be capable of running for long periods without attention and shall, as far as possible, be free from breakdown.

To meet these conditions Austinlite, Limited, Smethwick 40, Birmingham, have designed a fully-automatic duplicate-engine flywheel alternator set, of which a typical example is illustrated on this page. As will be seen, it consists of two 10-kW Diesel engines which drive a single alternator through semi-flexible couplings and magnetic clutches. Between one of these engines and the alternator is a steel flywheel.

The engines which are manufactured by R. A. Lister and Company, Limited, Dursley, are of that firm's multi-cylinder cold-starting compression-ignition type and are equipped with a radiator and fan to suit tropical conditions. To enable them to run for periods up to one month unattended they are each provided with dry-sump lubrication and with a large storage tank. The fuel and water tanks are also unusually large. Thermostats for regulating the water temperature and switches for controlling the lubricating oil pressure are included.

The clutches are of the Austinlite electromagnetic type and have easily replaceable friction linings. They are pre-aligned on either the main flywheel or the alternator shaft and run in ball bearings. The friction plates are coupled semi-flexibly to the engine flywheels. The clutches are energised from a battery through sliprings and carbon brushes.

The main flywheel is a machined steel forging which is fixed to the shaft by a taper and key. It is mounted in self-aligned ball bearings and is dynamically balanced after assembly. The bearings are carried in a steel housing, the inner cups of which are provided with phosphor-bronze sleeve bearings. These bearings have a clearance of 0·004 in. on the shaft and are designed to carry the flywheel until it comes to rest should the ball race fail. Bearing failure or undue wear is detected by built-in electrical contacts.

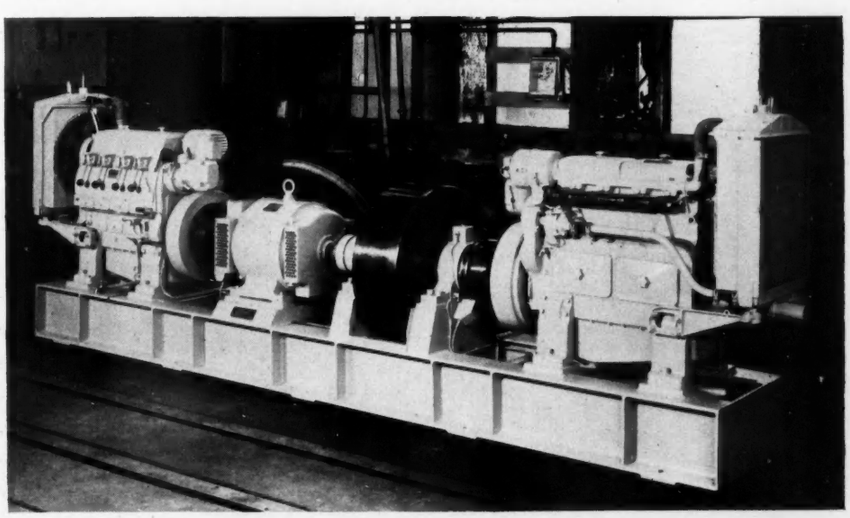
The alternator is semi-flexibly coupled to the flywheel at one end and carries one of the magnetic clutches at the other. It was manufactured by Electric Construction Company, Limited, Wolverhampton, and is of the enclosed ventilated type, the rating being such that the full output is maintained at reduced frequency during the change over from one engine to the other. Speed variations are detected by a centrifugal switch driven from the alternator shaft.

The overload circuit-breaker, engine control relays, alarm indicator lamps, static exciter and voltage regulator are installed in a floor-mounted cubicle.

OPERATIONAL METHODS

The set is brought into operation by first energising one of the magnetic clutches so that the corresponding engine is connected to the alternator and the set is then started by hand. The drive is changed over from one engine to the other automatically once a week by clutching in the stand-by which thus runs up to speed and takes over the duty. The first engine is then de-clutched. The same procedure is also followed should the engine in operation fail at any time, provision being made to indicate fault conditions and to give an extended alarm.

When operating normally the alternator voltage is maintained within $\pm 2\frac{1}{2}$ per cent., and the frequency within ± 1 per cent. During normal change over the voltage and frequency do not fall by more than 10 per cent., neither do they decrease by more than 12 per cent., while the stand-by engine is running up to speed after the duty engine has failed.



A fully-automatic double-engine set and alternator for use on unattended sites where there are no electric mains.

INTER-VEHICLE COMMUNICATION

Telephonic System Using Existing Power Lines

A telephonic communications system, which makes use of existing power lines for transmission, has been developed by the British Thomson-Houston Company, Limited, Rugby, for industrial purposes. The system has been evolved from the firm's " Clearcall " equipment already in use, and bears the same name. By it verbal messages can be transmitted from a fixed station to moving plant such as electrically-operated transporters or railway trains.

The system is based on a frequency-modulated carrier wave of high frequency which is fed into the existing power supply lines. Transmitters (which are actually modulators) and receivers can be coupled to the lines wherever they are required. The receiver is tuned to the carrier wave and reproduces the modulations through a loudspeaker as sound. As high signal strengths can be used, the receiving circuits can be very simple. By using more than one carrier, wave frequency the facilities can be extended, and equipment is available for carrying on 36 different conversations simultaneously over one pair of conductors.

Communication by such means is not limited to between one fixed point and a moving point, and experiments involving two moving points are to be undertaken by British Railways. These will be made along the electrified Manchester-Sheffield line on the Pennistone Bank where mineral trains sometimes require a banking locomotive at the rear. The system will give direct verbal communication between the drivers so that control may be synchronised. For this work two-way communication will be developed.

NON-ELECTRIFIED TRACKS

On railways where the lines are not electrified, the system can be used by laying a wire along the track and an aerial under the locomotive. The receiving equipment for such an arrangement is shown in the illustration mounted on a Diesel-electric locomotive. The de-modulator is mounted over the window at the left and the speaker is close to the driver's left ear. This method is particularly suitable for marshalling yards and has been demonstrated both at Rugby and Sudbury. It can completely replace coded signals on Klaxon horns and messages are unlikely to be misinterpreted. A system of this nature is to be installed as part of the reorganisation scheme at the Manvers Main colliery. It will be used from three shunting points using separate frequencies to control steam-locomotive traffic.

Above the window on the left is the receiver unit, and in the corner by the driver is the loudspeaker for communicating with the driver of this Diesel-electric locomotive by a high-frequency telephonic system.

* * *

SOUND MUFFLER FOR GROUND RUNNING OF JET ENGINES

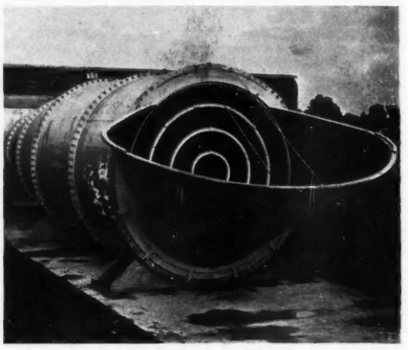
Running-up Pen Installed by Vickers-Armstrongs Limited

While the problem of silencing jet engines on test-beds has, to a considerable degree, been solved in recent years, the provision of silencing for engines installed in aircraft, when running-up on the ground, has proved to be more difficult. A promising solution has recently been put into operation at the Supermarine factory of Vickers-Armstrongs Limited, South Marston, near Swindon.

The muffler and running-up pen installed at South Marston, shown in the accompanying illustrations, were designed for the Avon-engined Swift fighter aircraft which are in production there. Previously, the necessary ground running was causing a serious noise nuisance to a local hospital and neighbouring villages, as well as within the factory, conversation being almost impossible when reheat tests were being carried out.

The muffler, which comprises a short jet-pipe detuner developed from those used in jet engine test-beds, was designed by Mr. Jack Cullum, managing director of Detuners, Limited, Flowers-mews, London, N.19. It is about 45 ft. long, whereas test-bed detuners are normally 80 to 90 ft. long. Briefly, it comprises an entry section in which the hot exhaust gases mix with cooling air, a diffuser through which the mixture of gases expands and cools, and a cast-iron and mild-steel reactor weighing four tons which reduces the transmission of low-frequency noise. Before and aft of the reactor the walls of the detuner are lined with different sound-absorbing materials, divided into compartments of different sizes and faced with perforated steel sheet, to suppress the various frequency bands. At the exit of the muffler the gases pass through a series of concentric baffles and are deflected upwards by a scoop.

The acoustic pen in which the muffler is incorporated was designed by Mr. Quentin Reeves, consulting engineer to the Hawker-Siddeley Group. As may be seen from the illustration, it consists of an open pen about 12 ft. 6 in. high, the muffler entry section being built into the back wall. The high walls have the incidental advantages of ensuring that the air drawn into the engine intakes is free from blade-fouling stones and dirt, and of eliminating the effects of wind on the test conditions. The walls are of 9-in. brick with a 3-in. rock-wool lining covered with canvas, with perforated aluminium sheeting over all; the acoustic materials being supplied by Horace W. Cullum and Company, Limited, Flowers-mews, London, N.19. The opening in the back wall is sealed around the muffler with a packing joint.



The Cullum muffler, showing the concentric splitters at the exit and the scoop which deflects the gases upwards.

A Swift in the running-up pen. Conversation is possible anywhere outside the pen—even with reheat operating.

The aircraft under test is moved into the pen by a tractor through the main doors in the front wall, which are then closed. The end of the jet pipe is centred in the flared entry to the muffler and the aircraft is restrained by two 5-ton steel wires attached to the fuselage just in front of the tailplane.

The acoustic running-up pen at South Marston was originally conceived as an experimental installation with the preliminary object of reducing the noise level of a reheat engine test down to, or below that, of an engine test without reheat. This meant a reduction of about ten decibels from a noise intensity of about 140 decibels. In fact, this objective has been surpassed. Tests carried out by the National Physical Laboratory have shown that, in a region where the noise level was previously about 140 decibels, with the new installation this level was reduced to about 100 decibels. Even with reheat in action, conversation is now possible anywhere outside the pen. The experience gained so far will enable the installation to be developed to reduce the noise level still further.

ELECTRONIC RESEARCH

SOME PROJECTS BEING CARRIED OUT BY FERRANTI, LIMITED, AT EDINBURGH

Among the many projects which are being investigated at the Ferranti research laboratories at Edinburgh is one concerning the electronic control of machine tools. One of the simpler applications is that shown in Fig. 1 where the movements of the jig-drilling machine are controlled from the panel on the right. In this, the co-ordinates of the point to be drilled are set up on the two banks of knobs, and the table will be moved automatically to the required position. The control knobs are calibrated so that the position can be set to within 0·0002 in., giving very accurate drilling. With an additional panel, the setting-up for each hole can be done from a punched tape without the need of an operator. Where more complicated machining is required, as in profile milling, a computer is introduced into the system which records on a magnetic tape the directions to the machine.

This system was described in some detail in ENGINEERING, vol. 177, page 766 (1954). Diffraction gratings are used to measure the movement of the machine slides.

Another project, and the one that was first carried out at Edinburgh, is the Gyro gunsight for use in aircraft which have fixed guns and where aiming is carried out by moving the aircraft itself. With this, the pilot first sets a " span control " to the wing-span of the aircraft he is attacking and adjusts the range control so that the circular pattern of light spots which is projected on the sighting glass, encircles the aircraft. The gyroscope in the sight is sensitive to rates of turn and generates an electric signal which controls the position of the light spots. As long as the pilot keeps the aircraft within the pattern, the guns are correctly aimed.

Fig. 1 By setting the knobs on the control panel on the right to the co-ordinates of a point, the work piece can be located for drilling to within 0·0002 in. Diffraction gratings, enclosed in the panels along the slides of the machine, measure their movement.

AIRCRAFT NAVIGATION

Distance measuring equipment is a navigational system for aircraft which provides the pilot with a precise indication of his distance from a fixed point on the ground. The indicator also shows whether the fixed point is in the direct line of flight or to one side of it. An interrogator unit on the aircraft transmits a signal to a beacon on the ground from which an echo returns to the aircraft. The equipment incorporates several sub-miniaturisation techniques and methods of high-speed production. The frequency of the system is controlled by feeding the output to two resonant cavities, one of which is turned slightly above and the other slightly below the set frequency. As long as the outputs from the cavities are the same, the signals neutralise each other, but if they differ, then a resultant signal goes to a motor-driven tuner and the frequency is corrected. Mismatch in the aerial line can be shown by standing-wave detectors; one employs a series of neon tubes along the guide which show the pattern of the wave, and the other has a crystal probe which can be slid along the guide and gives precise quantitative measurements at any point. A magnetostriction delay line controls the pulse-spacing. It utilises a strip of " Permandur " which expands momentarily with each pulse and the stress wave set up is detected and fed to the transmitter. The required delay can be obtained by spacing the impulse and detector coils along the strip.

AIRSTREAM DIRECTION

An instrument that has been developed to enable the pilot to trim an aircraft to reduce drag, and will indicate sideslip or angle of attack, is the airstream-direction indicator. This consists of a cylindrical steel probe which projects outside the aircraft and has in it two longitudinal slots set 90 deg. apart. The air pressures from these are fed to a paddle chamber where they operate on opposite sides of a very light paddle. This paddle is connected to the probe through a 10 to 1 gearing. If the pressures received from the slots are not equal, the paddle will rotate and turn the probe until they do balance. An electrical pick-off system then operates an indicator to show the pilot the actual direction of the airstream in relation to the aircraft, and he can therefore make any necessary adjustments.

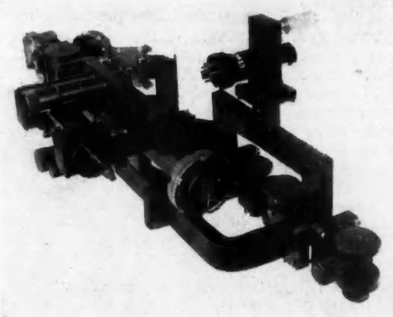


Fig. 2 A radar head built up from sections of wave-guides requires much space and very careful assembly.

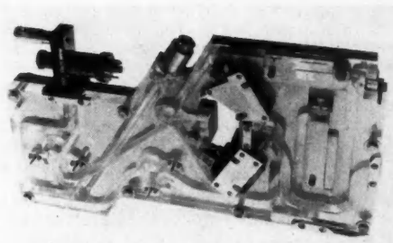


Fig. 3 The same head with the channels milled in a solid block can be rapidly produced by a copying process, is lighter and occupies less space. In this illustration the top half is made of Perspex to enable the channels to be seen.

" MILLED BLOCK " TECHNIQUE

A technique developed at the laboratories concerns the production of wave-guide assemblies for radar heads. Whereas formerly a complicated assembly of guides had to be built up in the manner shown in Fig. 2, a milled block can now be used as shown in Fig. 3. For the sake of illustration, the front half of this block has been made in Perspex to enable the channels to be seen. In practice both halves would be of aluminium. Building up from separate items involved much accurate assembly and occupied a considerable time. Also the actual manufacture of the wave-guides was a costly process. With the new technique, heads can be machined accurately and rapidly from a master copy. The two illustrations show clearly the saving in complexity and space required; there is also a saving in weight. Another example of this technique is the microwave test bench that was shown at the Scottish Exhibition. (ENGINEERING, page 326, *ante*.)

A series of transformers which have the core and windings completely embedded in a resin block has also been evolved. These have the high insulating qualities associated with the resin, and enable high-voltage units to be produced in a very small size. The solid block also gives an extremely robust construction. Sub-miniature techniques are also one of the projects at the laboratory and precision potentiometers form another line.

RESEARCH INSTRUMENTS

It is often necessary to determine the radiation characteristics of aerials mounted on aircraft. A recorder has been produced which will plot on a circular chart the radiation pattern of an aerial fitted to a scale-model aircraft. The use of a model has many obvious advantages over a full-size machine, and exact patterns can be obtained by making proper scale allowances. The recorder can be used equally well with full-size equipment if desired.

For similar reasons, an echo simulator has been developed for the instruction and training of traffic controllers. The " pilot " can fly the " aircraft " under the ground-controllers' regula-

tion, the echo being produced on the controllers' screen. Full account is taken of changes in speed, rates of turn, and wind drift in the production of the echo. A number of simulators can be used together and their echoes presented simultaneously on the radar display screen. Many other instruments for test work are also being developed by the firm.

* * *

FERRANTI RESEARCH LABORATORY

New Buildings Opened at Edinburgh

A new laboratory block for research work at the Ferranti factory at Edinburgh was opened by H.R.H. the Duke of Edinburgh, on October 11. In his speech, the Duke drew attention to the uses of electronics in defence and in industry both alone and as an aid to machine-tool control. The laboratories were erected in conjunction with the Ministry of Supply to implement the Scottish Council's scheme for the development of the electronic industry in Scotland.

The three-storey block has a floor area of about 55,000 sq. ft. and accommodates 24 project laboratories with associated offices, two drawing offices, print rooms and other offices. In addition there is a climatic and durability test room and a dust proof air-conditioned laboratory for special work. The architect was Mr. D. H. Bamber, A.R.I.B.A., of Fairbrother, Hall and Hedges, 27 Rutland-square, Edinburgh 1.

The building has a reinforced-concrete frame, but the columns and beams, instead of being covered in, are exposed on the elevations as an architectural feature. The spaces beneath the windows are filled with golden-brown rustic bricks and the elevations at each side of the tower (the building is L-shaped with the tower at the angle) and also those at the end of each wing are covered with Canterbury quartz chips on a blue background.

The tower is 65 ft. high and in it are the main staircase and the lift. The staircase window is 10 ft. wide and 48 ft. high. Beneath the tower is the entrance hall. The internal planning of the laboratories is arranged on a 12-ft. by 12-ft. grid so that there is flexibility in sub-division of the areas to suit the project in hand. Glazed steel partitioning is employed for the divisions and can be easily re-arranged. Ducts for all services run along the corridors and connect with vertical ducts on the inside walls of the laboratory areas. Nine electrical supplies are fed to panels in the laboratories, together with gas and compressed air. Adjustable fluorescent lighting is used in the laboratories and drawing offices. The lighting installation was carried out by the Edison Swan Electric Company, Limited, 155 Charing Cross-road, London, W.C.2, a special type of louvred Perspex fitting for side mounting being used as they could not be fixed to the ceilings owing to the panel-heating equipment.

A single boiler plant supplies both the old and the new blocks, steam being piped across to the roadway to a calorifier chamber where the circulating water for the new building is heated. A series of continuous pipe coils were embedded in the ceilings during construction, and through them the hot water, at about 120 deg. F. is circulated. This gives a form of radiant heating which is not affected by air currents from doors or windows and is completely dust free. Each wing of the block has separate thermostatic controls.

The air-conditioning plant supplying the dust-free laboratory maintains the temperature to within ± 1 deg. F. and the humidity within ± 2 per cent. Electrostatic filters clean the circulating air. In the climatic test area there is a sunken chamber fitted with showers and sprays to imitate driving rain, as well as ovens for temperature and humidity tests. The durability room has provision for vibration and shock tests of components or complete equipment.

BAGHDAD TRADE FAIR

BRITISH GOODS DISPLAYED IN THE MIDDLE EAST

Conclued from page 508

We give below some more descriptions of British-made articles and equipment to be displayed at the Baghdad Trade Fair which will be open from Monday, October 25, until Monday, November 8.

ELECTRIC MOTORS AND LIGHTING

Crompton Parkinson, Limited, Crompton House, Aldwych, London, W.C.2, are displaying a large number of their products including switchgear and generator sets. Some of the latter are supplying power to the Fair and some of the firm's lighting fittings are also being used. A lamp of special interest in the tropics, the "Buzz away," gives a light which does not attract insects. Several other firms are also exhibiting motors and generators, including the Brush group, Dale Electric, Limited, English Electric, Limited, and Skylon Engineering, Limited.

In addition to motors and generators, Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, are showing switchgear, welding equipment and lighting units. A dual-motor drive for textile spinning frames, using Fenner's variable-speed pulley is also being shown as applied to a Platt ring spinning frame. This arrangement allows squirrel-cage motors to be used to give the benefits of a variable-speed drive while only employing a simple control system. It is said to give greatly increased outputs. Another Metropolitan-Vickers exhibit is a fluoroscope which is independent of any electrical supply and can be used as an inspection instrument anywhere in the field. A crack detector is also being shown.

VEHICLE SPARES

Spare parts for vehicles are always required and some are being shown by C. J. Fox and Sons, Limited, 117 Victoria-street, London, S.W.1. The parts shown are British made and are replacements for use on American vehicles. Items such as radiators and springs are included as well as smaller parts. Other exhibits by the firm include the Cubicold refrigerator display counters and a motor mower.

MOTOR VEHICLES

Several motor vehicles will be shown, including a Bentley and some from the Rootes group. Commercial vehicles and chassis are being shown by Leylands and also by Dennis Brothers, Limited, Guildford. In addition to a 12-ton payload six-wheel chassis, the latter are showing the trailer pump illustrated in Fig. 7. This unit is primarily designed for emptying cess-pools in heavily built-up and congested areas where manœuvring is limited. After being towed to the site, it can be handled by two men. The pump unit evacuates the 150-gallon tank, and the sewage is sucked up into the latter. An air-cooled Dennis petrol engine drives the pump which is of the Hammond rotary type. The air system can be reversed by a two-way valve to allow the tank to be emptied by pressure.

SHEET METAL MACHINES

F. J. Edwards, Limited, 359-361 Euston-road, London, N.W.1, are exhibiting a selection from their range of machines for sheet metal work. Among them are a motorised swaging and wiring machine (illustrated in Fig. 8) and a hand-operated folding machine. The swaging machine is capable of working mild steel up to 14 s.w.g., either flat, round or cylindrical. Pedals control the operation, enabling the work to pass through in either direction; a guard between the pedals prevents their simultaneous operation. There is an adjustable guide which can be slid along the throat so that a swage can be kept at a constant distance from the edge of the work. The hand-operated folding machine will take mild steel up to 18 s.w.g. for box and pan making. The maximum width that can be accommodated is 49 in.

PUMP FOR CHEAP FUELS

Among the exhibits of Tangyes, Limited, Smethwick, Birmingham, which include hydraulic equipment and a Diesel-generator set supplying the light for the stand, is a fuel-pump for Diesel engines which is designed to handle the cheap fuels available locally. These fuels are rather abrasive and helical fuel pumps, made to very close limits, are quickly worn. The Tangye pump has a simple plunger with a packing gland which allows adjustment for wear if required. Use of this pump enables low-speed open crankcase engines to be run on the cheapest fuels available. As these have a low pour point, heating may be necessary, and for this a heater, connected to the exhaust, is included. With fuels that are very heavy, it may be necessary to start the engine on gas oil and run it until the

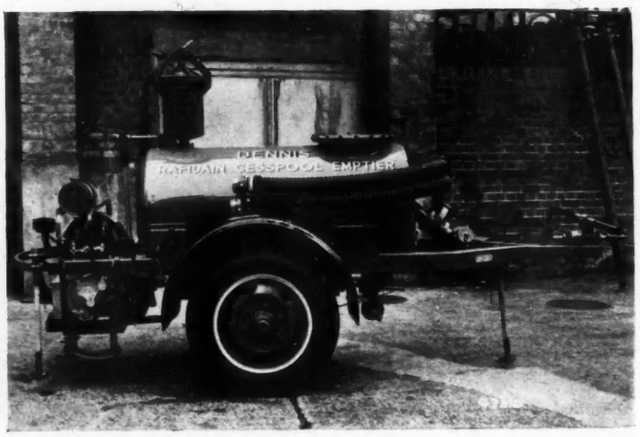


Fig. 7 Trailer pump designed for emptying cess-pools. A Hammond rotary pump is used to evacuate the 150-gall. tank and the sewage is drawn up into the tank. A two-way valve enables the tank to be emptied by pressure.

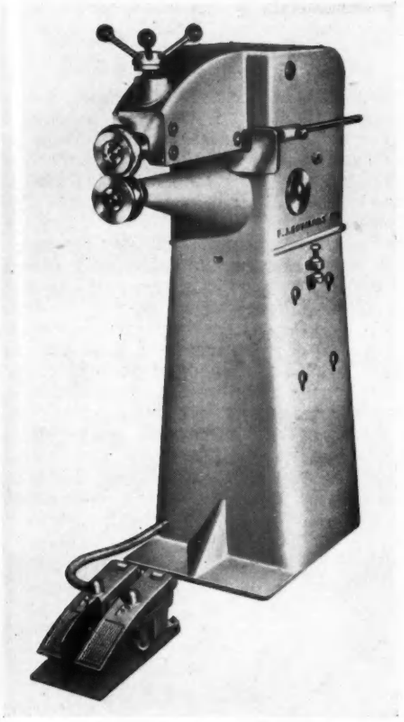


Fig. 8 Pedal-operated swaging and wiring machine capable of working mild steel of 14 s.w.g.

cheap fuel is warm enough to be used before changing over. The change back to gas oil should be made before shutting down, so that the correct fuel is available for restarting. These pumps are interchangeable with the helical pumps normally fitted.

DIESEL ENGINES

Most of the larger manufacturers of Diesel engines are exhibiting at the Fair, including Rolls Royce, Limited, who are also showing a Dart propeller-turbine engine and a cut-away model of a Derwent. W. H. Dorman and Company, Limited, Stafford, are showing three engines made up in power pack form. The most recent of these is the three-cylinder version of the L series which will now comprise three-, four- and six-cylinder engines for which the rated outputs at 1,800 r.p.m. are approximately 44, 65 and 96 h.p. Cast-iron cylinder blocks are used with "chrome-hardened" wet liners. The drive is normally through a Rockford clutch.

COOLING AND AIR CONDITIONING

Air conditioning of buildings in hot countries is almost a necessity and equipment is being exhibited by several firms. F. H. Biddle, Limited, 52 Clerkenwell-close, London, are showing a range of plant from a single-room cooling unit to a plant for an entire building which will control both temperature and humidity. Brentford Electric, Limited, Kidbrooke Park-road, London, S.E.3, are exhibiting the domestic heat pump which is illustrated in Fig. 9. The unit is 2 ft. square and 4 ft. 6 in. high, there being a storage space in the cupboard at the top. It requires approximately 300 watts to drive, and will maintain the larder space at approximately 40 deg. F. while heating 30 gallons of water to 140 deg. F. The water supply pipes can be seen leading away to the right of the unit and a standard domestic system can be used. Coolers and heat exchangers are being shown by the A.P.V. Company, Limited, Heenan and Froude, Limited, J. Stone and Company (Deptford), Limited and some others.

TEXTILE MACHINES

Among textile plant, the British Northrop Loom Company, Limited, Blackburn, are exhibiting an improved version of an automatic single-shuttle loom for light to medium weight materials. Machines are available for weaving fabrics from 20 to 56 ins. wide. A cotton card machine and a ring spinning frame are being shown by Platt Bros. (Sales), Limited, Oldham. Two standard sizes are made, of 40 and 45 in., and they can take 9, 10, 12 or 14 in. coiler-cans. These machines are claimed to be simple and accurate to set up and to have a flexible production range for both light and heavy carding.

LIGHT BUILDINGS

There are several examples at the Fair of light structures for sheds and houses. Some of the pavilions are built of Taylor Woodrow's Arcon prefabricated structures. This type of construction was described in ENGINEERING, vol. 175, page 543 (1953). The Bristol Aeroplane Company, Limited, Oldmixon, Weston-super-Mare, are showing a two-room school building in their mark III form of construction for hot climates. A prototype of this was exhibited at the British Industries Fair this year. These buildings are of aluminium with an inner lining to the panels of non-combustible wall-board and are designed as permanent structures.

WATER PURIFICATION

Imperial Chemical Industries Limited, Imperial Chemical House, Milbank, London, S.W.1, are showing on their stand a model of a floating water purification plant. Pure water is a most precious commodity in outlying communities and this plant can be towed up a river to the point where it is required. Water is drawn from the river and purified on board the plant, being afterwards pumped to the spot where it is needed. The float is constructed mainly of light alloy and is completely mobile. The first full-size plant is due in Iraq towards the end of the year, and will have a capacity of 2,400 gallons per hour when pumped against a 70-ft. head.

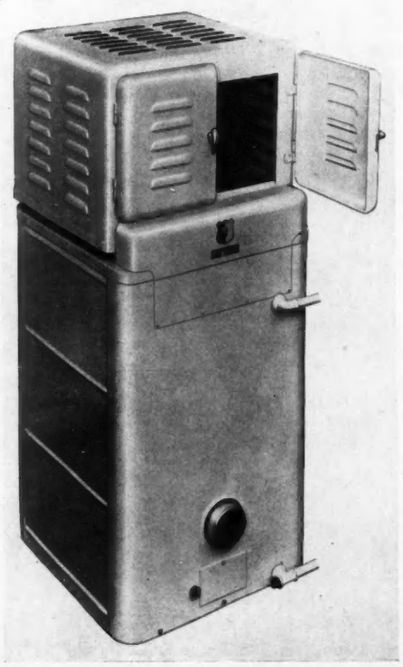


Fig. 9 Domestic heat pump which will maintain the larder space at 40 deg. F. while heating 30 gall. of water to 140 deg. F. for a consumption of 300 watts.

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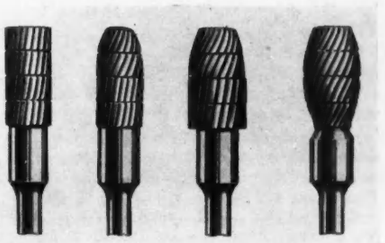


The "Segbur" is built up from a number of tungsten-carbide segments brazed on to a standard shank. The shape can be varied or a damaged segment replaced in a few minutes using an ordinary brazing torch.

TUNGSTEN-CARBIDE BURS

Built-Up Construction

The bur, or rotary cutter, has been used extensively for such work as dressing castings and die-sinking for many years. For a long period hardened steel burs were satisfactory, but the development of alloy steels and other special alloys in recent years has made it necessary to use tungsten carbide. This has been done successfully and burs of this material are in regular production. As they are ground from the solid, however, and can only be re-ground in special machines, their cost is high. Further, the solid bur has the disadvantage that if a tooth is chipped, deterioration of the remainder of the teeth is rapid, and the life of the bur is short. Because of their high cost, the use of solid tungsten-carbide burs has tended to be restricted to work which was difficult, or impossible, by other means. Many possible applications of the tool have not been developed because the advantages of the bur were offset by the high costs of purchase and maintenance.

To overcome the difficulties inherent in the solid-ground tungsten-carbide bur, Flexible Drives (Gilmans), Ltd., 195 High-street, Smethwick 41, Staffordshire, have introduced the "Segbur." This is a tungsten-carbide bur which is built up from segments brazed on to a shank to produce the required shape and size. Each segment is moulded to shape before sintering, in accordance with normal tungsten-carbide tool-making practice. The shanks are standardised at 6 mm. diameter, but 8 mm. and ¼ in. diameter shanks are also available. The tungsten carbide segments are marketed in three grades: blue, a medium grade for general use; yellow, which is tough, and specially suitable for working Nimonic and similar alloys; and red, a hard grade for cutting hardened tool steels.

The segmented construction has several advantages. By moulding instead of grinding from the solid, the cost of production is reduced considerably, and a segmented bur can be supplied at approximately half the cost of a solid-ground one. The built up construction makes it possible to assemble a large variety of shapes from a relatively small number of segments, and the shape of a bur can be altered by the user if necessary. If a tooth is damaged, the affected segment can be removed, and a new one brazed in position in a few minutes, in the user's works. Finally, the form of the tooth is such that the complete bur can be re-sharpened by spinning the bur lightly by hand against a suitable grinding wheel, or by power-rotating it against a silicon-carbide lapping stick held in the hand.

The Motor Show at Earl's Court, London (October 20 to 30)

TRENDS IN THE DESIGN OF MOTOR CARS

1—STATION WAGONS: SUSPENSION SYSTEMS

This year's Motor Show at Earl's Court finds the British industry in a crucial phase of its development. The difficulties of the small manufacturer multiply as the larger groups plan expansion programmes to meet the challenge of the big schemes of extension and re-equipment announced by two major producers who are under foreign control—Ford and Vauxhall. Jowett are no longer in the car business, Lea Francis refrain from exhibiting while awaiting better times, Singer have announced their intention of extending their activities in directions apart from the motor industry, while the production of high-quality specialist cars by companies like Rolls Royce, Bentley, Bristol, Armstrong Siddeley, Aston Martin and Lagonda gains immeasurably from the facilities which are made available through associated activities in other fields.

As the structure of the industry changes, so do its products. This year's show reveals the pattern of the rationalisation process which has been going on within the British Motor Corporation for some time; a process which has among other things entailed the removal and re-siting of some 14,000 machine tools. The A-type 800-c.c. engine is now installed in the Austin A30 and Morris Minor cars, and their station wagon and light commercial variants. The B-type engine, with variations of cylinder bore to give 1,200 or 1,500 c.c. and differences in carburation and other details, is now found in the Austin Cambridge A40 and A50, the Morris Cowley and Oxford and the M.G. Magnette, while the new C-type six-cylinder powers the Austin A90 Westminster and the Wolseley 6/90 Six, two new cars whose announcement has been kept back until the opening day of the Show. The process is not yet complete, but it is supported by a heavy expenditure on transfer machine tools, and may well lead to the production of engines and gearboxes at prices so attractive that other manufacturers may buy them. Standardisation is also extending throughout the accessory and component industries, though the full potential economies have not yet been realised.

The changing pattern of public demand is reflected in the large number of new station wagons at the Show. This versatile vehicle, with its smart appearance and large carrying capacity, fills a dual role: it is a family car which can earn its keep in business. Development has been retarded in Britain by the law which appeared to make such vehicles liable to observe a 30 m.p.h. speed limit at all times, but a decision of the courts to the effect that the limit did not apply when goods were not being carried has had the effect of encouraging production. Broadly speaking, there are two approaches to the design problem; the conventional coach-built structure, with metal panels attached to a wooden frame, and the all-metal job evolved from a set of pressings which may also do duty for a light van. Morris have adopted the former approach on the Minor and the Oxford. The Minor saloon is a unit structure, but for the pick-up and van a ladder-type chassis is used, with box section side and cross members. Use of this chassis would have entailed an excessive overall height at the rear of the station wagon, so the base pressings of the saloon are used, with box-section reinforcements at the rear wheel arches to carry the spring shackles. Body framing aft of the front cab is in wood with steel gusset plates. The panels on the Minor are aluminium, but steel is used on the Oxford (Fig. 2).

The Standard Motor Company appear to have drawn more from their saloon than from their van for the Standard Ten station wagon. This vehicle has four doors at the sides and two at the rear, an apparent multiplicity which is reflected in a fairly high price. The van approach is seen in the Hillman Minx estate car, though for the Husky (Fig. 1)—a smaller, lighter and much cheaper car—a new set of rear pressings was evolved, still using the front end of the saloon unit structure. Roof and screen frame form one pressing, with rain gutters at the edges. Box-section reinforcements run right through to the rear under the floor, despite the low overall height, and a good deal of torsional rigidity must be gained from the steel inner floor over the spare-wheel compartment, joining the two wheel arches to form a box. There are only two wide doors, and a single rear door opened from inside. Incidentally, the door construction at the rear is interesting. The inner and outer halves of the door are spot welded together on flanges turned at right angles, in contrast to the usual method where the outer panel is clinched over on the inner all round the edge of the door, an operation which used to be costly, and an unpopular one with the operators.

The use of wood framing is still favoured by buyers in some markets, where it conveys a sense of hand craftsmanship, but it has obvious limitations in tropical climates. American manufacturers have for some time compromised by using wood veneers bonded to steel panels, with imitation wooden structural members applied at the edges, but even this appliqué woodwork demanded periodical varnishing. Much of the apparent woodwork seen to-day on American station wagons is in reality specially-treated resin-bonded Fibreglass.

In terms of carrying capacity for a given wheelbase, these conventional vehicles cannot compare with the steel-box layout exemplified by the Volkswagen "Microbus" (Fig. 3). This vehicle is one of a whole range, comprising van, station wagon, pick-up and ambulance, all derived from the same basic structure. The suspension, steering, engine and transmission of the saloon are used, with transfer gears on the hubs at the rear to increase the ground clearance. They are hung on a steel box, with the driver sitting over the front wheels and the engine overhung at the rear, leaving the whole centre section and a substantial space over the engine available for goods or passengers. The load capacity of the conventional small station wagon is quoted as 4 to 5 cwt., apart from the occupants of the two front seats, but the Volkswagen box, with its little 1,192-c.c. air-cooled engine, contains 162 cub. ft. of space behind the driving compartment, and will carry eight people at 50 m.p.h. In van form it has a payload of

Fig. 1 The Hillman "Husky."

Fig. 2 The Morris Oxford "Traveller."

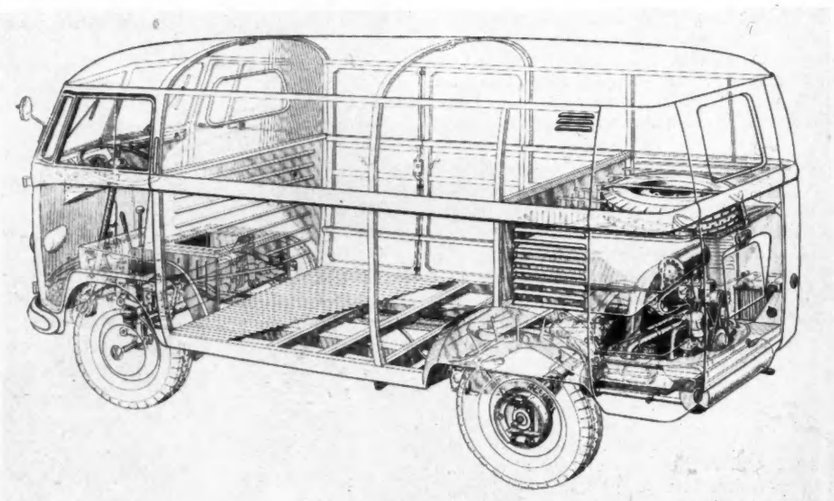


Fig. 3 The Volkswagen "Transporter," which has a remarkable carrying capacity in relation to the size of its 1,192-c.c. air-cooled engine.

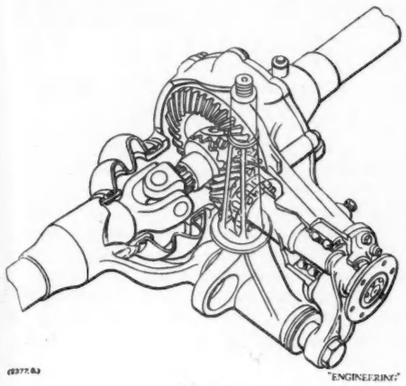


Fig. 4

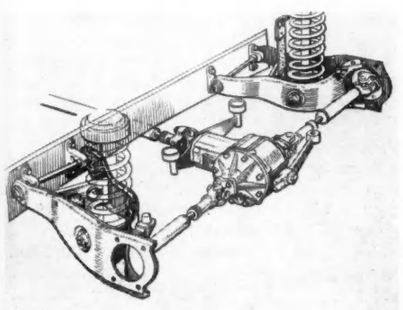


Fig. 6 Rear-wheel independent suspension of the Renault "Frégate" which gives exceptional riding comfort.

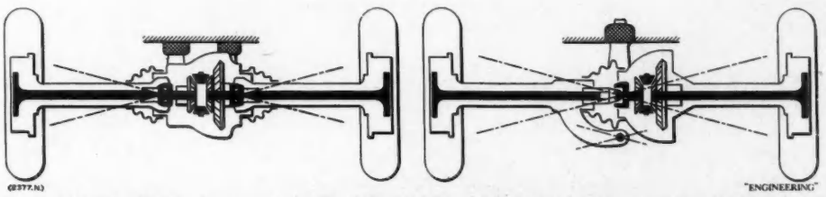


Fig. 5 The new design of rear axle for the Mercedes Benz Type 220 is shown on the right, with the previous arrangement on the left. By pivoting the half-axles about a point below the differential a low roll centre is achieved. Fig. 4 is a detail view. A diagonal link, not shown, locates the assembly laterally.

2,204 lb. including driver, for a vehicle weight of 1,984 lb. The pick-up will carry 300 lb. more than its own weight. This interesting design is being widely copied on the Continent.

In saloon-car design passengers are now seated between the wheels on practically all new models, but there are still ways to obtain more useful space which are not fully exploited. British manufacturers have been fairly slow to adopt the high rear-wing line, which enables the size of the luggage lock to be increased and improves visibility of tail and stop lamps and direction indicators. The Hillman Minx was one of the first, the new Rovers have it and the latest Austins are moving in the same direction.

PROPELLER-SHAFT TUNNEL

Progress in abolishing the propeller-shaft tunnel in the floor awaits a re-arrangement of transmissions and a wider use of independent rear suspension. The Renault Frégate, with its almost unbroken expanse of floor at front and rear, is an instructive example of what can be done. It is a five-six seat car with normal headroom, yet the overall height is only 60¼ in. It has a unit structure, and the gears in the gearbox are all indirect, allowing the output shaft to emerge at the bottom of the box, below crankshaft level. A small-diameter propeller shaft then runs in bearings close below the floor to the differential unit, which is attached to the structure by rubber mountings at the rear. The rear wheels are independently suspended (Fig. 6) by coil springs and single wishbones, which are almost fully trailing, having their pivots at a slight angle to the transverse axis. In practice this layout gives exceptional riding comfort and the car is free from the over-steer characteristics which make so many independently-suspended cars tricky to handle.

Daimler Benz, who have spent many years on the development of independent swing-axle suspension at the rear of their Mercedes cars, have evolved an interesting refinement for the Type 220 (Figs. 4 and 5). In the past this type of suspension has led to over-steer, because of the roll stiffness combined with a high roll centre; and changes of wheel angle with spring deflection have led to sudden variations in the cornering power of the rear tyres, with results which could

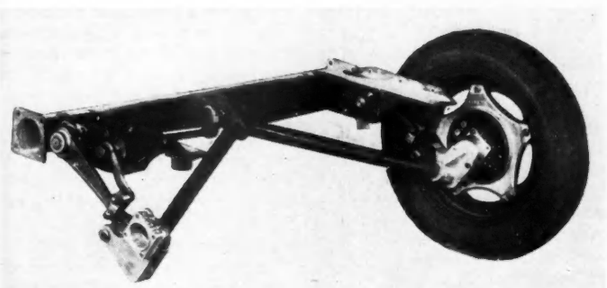


Fig. 7 The Panhard "Dyna" rear suspension, employing a triple torsion-bar arrangement.

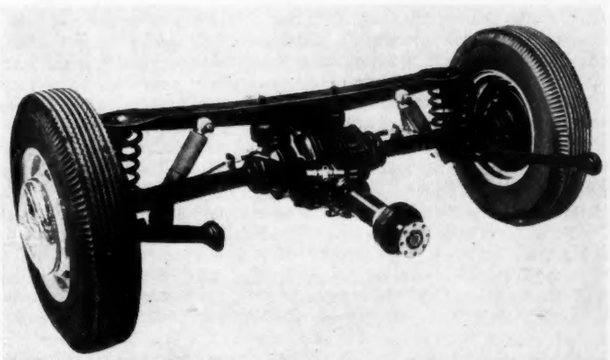


Fig. 8 Swing axles located by longitudinal radius arms mounted in rubber, as used on the Borgward Hansa 1500.

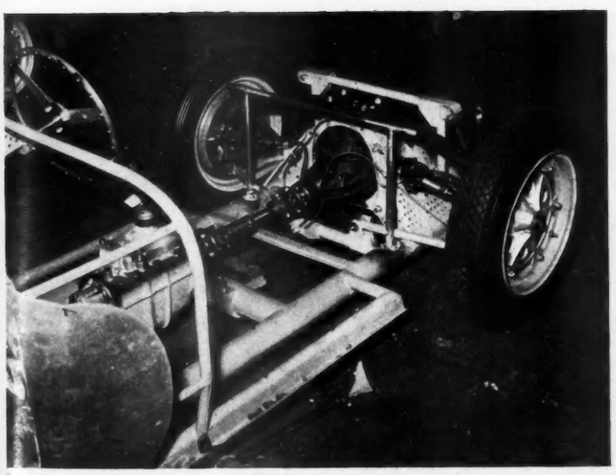


Fig. 9 Rear suspension of the Kieft 1100, using a transverse leaf spring with a single wishbone each side.

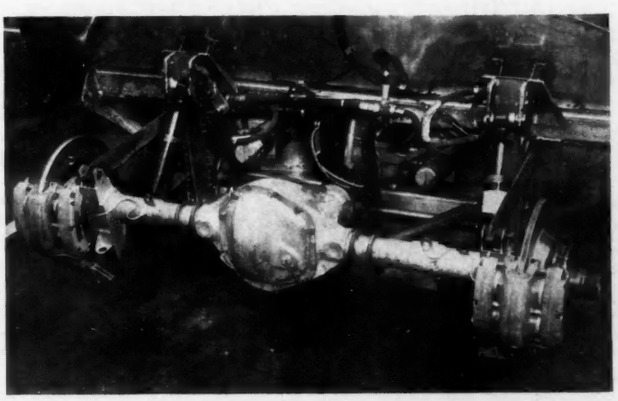


Fig. 10 Rigid rear axle of the Jaguar Type D, suspended on twin parallel trailing arms. The disc brakes are also visible.

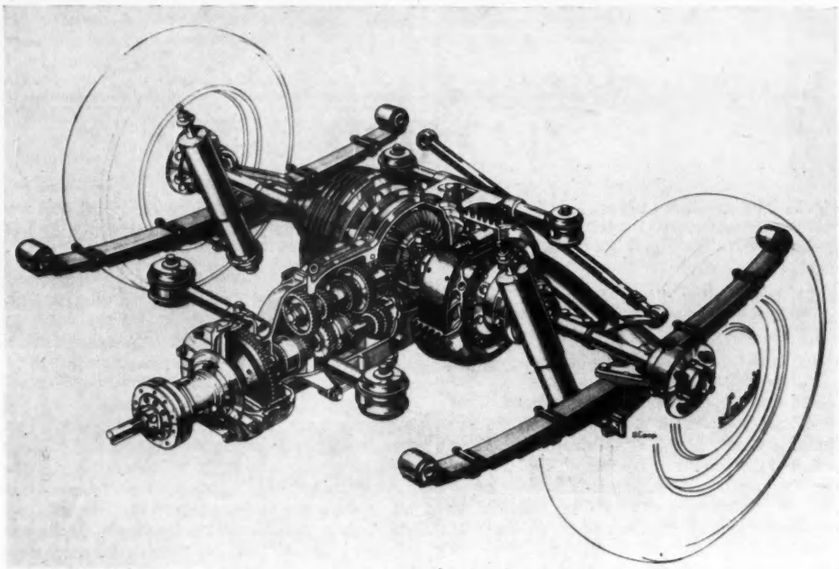


Fig. 11 A reversion to a de Dion axle arrangement on the Lancia Series 2 "Aurelia."

be disconcerting on fast cars. The new arrangement achieves a low roll centre by causing the half axles to pivot about a point below the differential. The final-drive unit itself is attached to one of the swinging half axles and pivots with it. This layout also gives the maximum length of axle for a given wheel track, and so reduces angular movement of the wheels as they rise and fall. It requires only one universal joint. There is of course a good deal of end-wise movement on the shaft connecting the universal joint to the opposite side drive shaft, and instead of conventional splines the shaft carries three radially disposed flat blades, which slide between lines of roller bearings contained in a steel housing.

LOW ROLL CENTRE

The low roll-centre layout will probably be extended to all production models when manufacturing arrangements allow, but meanwhile the Type 180 saloon gives very good results with swing axles located by longitudinal radius arms mounted in rubber, and a similar arrangement is used on the Borgward Hansa 1500 (Fig. 8), an interesting small German family car with a high performance.

The wishbone and coil-spring suspension used on the Lancia Aurelia was regarded as a very successful layout, similar in general conception to that on the Renault Frégate, but on the Series 2 Aurelia it has been abandoned in favour of a de Dion axle (Fig. 11). It is understood that the reason here is one of manufacturing costs and some of the sports models entered in competitions still have the independent suspension. The new suspension reverts to the arrangement used by the Marquis de Dion half a century ago, having two half-elliptic springs. These locate the axle, but are supplemented in this function by a transverse Panhard rod.

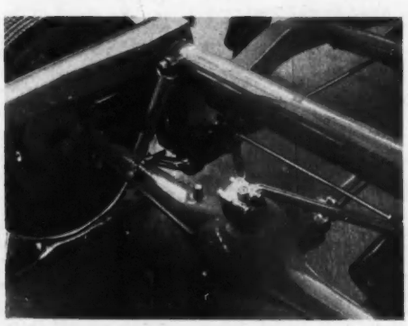


Fig. 12 The rear axle of the BMW 501.

Several of the British sports cars in small production use a system of independent rear suspension by a transverse leaf spring with single or double wishbones. On the Kieft 1100 a single wishbone is used each side (Fig. 9), but on the high-performance 1500-c.c. models, as on the Jaguar-engined Coopers, double wishbones are used to relieve the leaf spring of torque loads.

Even where the designer decides to retain a rigid rear axle, there is a growing tendency to locate it as precisely as possible. The Jaguar type-D sports racing car has an axle (Fig. 10) attached to twin parallel trailing arms, the lower arms being splined to transverse torsion bars. The attachment of the arms to the axle permits some flexibility as the wheels rise and fall, and the roll centre for the body is really fixed by the stout central triangular link carrying a pivot pin which engages in a bracket below the differential. The height of this bracket can be varied, thus permitting slight modifications in the car's handling characteristics so as to suit different circuits.

The B.M.W. chassis shows another arrangement, which has proved very successful on fast cars (Fig. 12). It is the starting point from which the Bristol and Frazer Nash suspensions were developed. The axle is shackled to two swinging arms connected to very long longitudinal torsion bars, and is located centrally by a small A-shaped arm, carried in pivots on the chassis and engaging in a ball joint on the axle. The new Alfa Julietta sports car has radius arms and coil springs, with an off-set arm at the side of the final drive casing to locate the axle laterally.

There seems to be little that is new in the evolution of progressive-rate arrangements for rear suspension. Panhard started by using a large rubber cushion of unusual shape to supplement the torsion bars on their light-alloy Dyna car, where the possible load forms an unusually high proportion of the all-up weight, but they have abandoned it and the torsion bars (Fig. 7) now do the work alone with apparent success.

To be continued

GROUND MOVEMENTS OF AIRCRAFT

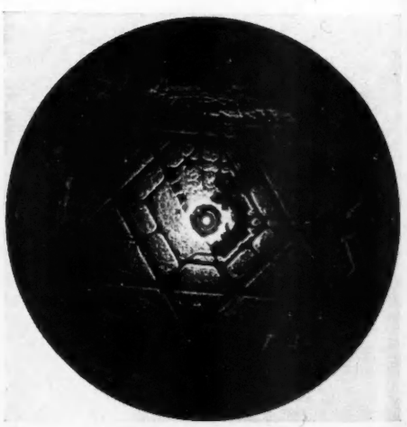
Millimetre Radar Equipment at London Airport

In view of the increased amount of traffic that London Airport will have to handle, the Ministry of Transport and Civil Aviation decided that an improved system for the control of aircraft on the ground would have to be installed. For this purpose, Decca Radar Limited, 1-3 Brixton-road, London, S.W.9, have developed a ground scanning equipment operating in the 8-mm. band. This Airfield Surface Movement Indicator will provide the control staff with an accurate picture of the movements of aircraft on the ground which will not be affected by conditions of poor visibility.

The primary feature of the new set is the high discrimination. This is derived from the narrow beam (horizontal angle, 23 minutes) and the short pulse (0·05 microseconds) which it employs, and the set is capable of providing the precise information at short range on the movement of aircraft and other vehicles that is required during the operation of large modern airfields.

The high definition actually obtained can be seen from the illustration, which is reproduced from a photograph taken during trials at the airport. The outlines of all the runways can be clearly seen, and on the lower horizontal runway are shown three positions of an aircraft which is taking-off, as recorded by successive sweeps of the scanner. A second aircraft can be seen in the top right-hand corner awaiting orders though, at present, this region is partly masked by an obstruction which will be removed when the equipment is permanently installed. The trace of the main road leading to the existing airport buildings can be seen running across the top of picture and above the outer runway. The site of the scanner was on the top of the control tower. A 12-in. diameter display screen is used.

The main functions of the installation at the airport are: to enable the control officer to see when the runway is clear; to direct rescue vehicles in bad weather; and to enable quick ground movements to be carried out in safety. It is not at present intended that all directional guidance shall be given from use of the indicator; lighting and stop-bars will continue to provide some of the route guidance for aircraft on the ground.



The high definition and discrimination obtained on the radar screen can be seen in this illustration. The movement of the aircraft along the lower runway was obtained by recording three successive sweeps of the scanner.

Labour Notes

TRANSPORT STAFFS: CONDITIONS IN 1953

Substantial increases in wages and salaries, which were granted by the British Transport Commission to its employees in 1953, have been supplemented during recent months. These increases, together with the rises which have occurred in maintenance and operating costs, were referred to by Sir Brian Robertson, the Commission's chairman, at a Press conference on October 13, as some of the main reasons why the Commission's final net surplus of £4,200,000 for 1953, was not likely to be repeated in 1954.

The Commission's sixth annual report, for the year ended December 31, 1953, shows that, while the total number of its employees declined by some 15,400 during the preceding twelve months, to just over 865,400 at the end of the year, the advances in wages and salaries conceded during 1953 alone were at the rate of £7,630,000 for a full year. No detailed estimate has been issued of the cost of increases approved during the present year.

Employees in the service of the Commission are engaged in a wide diversity of occupations, including, for example, engine drivers, lock-keepers, chefs, master mariners, and operatives in practically all branches of civil, mechanical and electrical engineering.

COMPLICATED NEGOTIATING MACHINERY

Many factors affect the Commission's policy on staff problems, such as the great variety of occupations involved, the large numbers employed, the dispersal of employees over wide areas and the consequent problem of maintaining contact and supervision, and the necessarily complex character of the industry's negotiating machinery.

Locations at which the Commission's staffs are employed vary from those where factory conditions obtain, as in the large manufacturing and repair shops at Derby, Crewe and Swindon, to isolated places far from the nearest village. Many traffic operatives, the report points out, have special responsibilities to the public, and the safety of both passengers and colleagues may depend on their good discipline and careful observance of standard procedure. Many men work alone.

A wide variety of negotiating arrangements are in force. The bulk of the railway staffs are covered by agreements with the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen and the Transport Salaried Staffs' Association, but the wages and conditions of the hotel and catering staffs are governed by Orders issued by the Catering Wages Board, and the cross-Channel marine employees are affected by decisions of the National Maritime Board. The workshop grades, comprising more than 100,000 men, have their own particular pay code, which is independent of the others but has a special relationship with that of the engineering industry. Similarly, the wages and conditions of bus drivers and conductors employed by the London Transport Executive and other bus groups have a relationship to those of undertakings outside the Commission.

WAGE RATES AND PENSIONS

During 1953, the Commission received claims for increases in pay in respect of the great majority of its workpeople, including employees of British Railways, British Road Services, the provincial and Scottish road passenger services, and the London Transport Executive.

It is stated that the increases sought were so substantial that the Commission was unable, in view of its financial position, to accept the demands, which amounted in many instances to 15 per cent. of existing rates and would have added about £15 millions to the annual bill for wages and salaries.

A grave situation arose, but agreement with the unions was reached on December 16. In general terms, this provided for an immediate increase of 4*s.* for male adults, with proportionate additions for women and juveniles, and for a further improvement at a later date on a percentage basis. It was also agreed that the two sides should examine the whole wage and salary structure in the railway organisation and that the unions would confer on ways of increasing efficiency.

Good progress was made during the year with the establishment by the Commission of a pension scheme for the wage grades of British Railways, the docks and inland waterways section, the hotel and catering services, the London Transport Executive, and at the Commission's headquarters. In this connection, it may be mentioned that an announcement was made in July last that the scheme would take effect from October 1, 1954.

SUGGESTION SCHEMES, WELFARE ARRANGEMENTS, AND TRAINING

One of the most interesting sections of this part of the report is that relating to the Commission's staff suggestion schemes. It is recorded that some 7,500 suggestions were received from members of the staff of British Railways during the past year. Of the total number of suggestions put forward, 842 were adopted, and awards made in respect of these proposals amounted to no less than £2,357. In addition, a sum of £719 was paid for a number of suggestions, which, although not adopted, were considered to merit awards.

During 1953, the Commission authorised expenditure in the region of £2 millions upon staff welfare. The money was spent, in the main, upon providing new offices, staff hostels, rest rooms, first-aid accommodation, and recreational and catering facilities. Much, it is admitted, remains to be done, but the Commission considers that steady progress is being achieved, on the basis of a priority list agreed with the trade unions.

A high proportion of the employees enter the Commission's service needing some instruction in the technique of their jobs. The Commission accordingly attaches great importance to education and training, especially in the case of apprentices and juniors.

During the year under review, particular attention was paid to problems connected with the recruitment and training of personnel capable of eventually filling high positions in the organisation. Contact was maintained with universities throughout Great Britain, with the object of attracting to the railway service suitable graduates, particularly those with engineering qualifications.

The Commission possesses residential staff-training colleges at Darlington, Watford and Woking, at which full-time courses are provided. From British Railways alone, 1,271 students attended full-time courses during the year.

TRANSPORT COMMISSION'S CENSUS OF STAFF

In conformity with the Commission's established annual procedure, a census of its staff and their average rates of pay and earnings was taken in respect of the week ended March 27, 1954. The results were published last week as a separate brochure from the annual report, under the title *British Transport Commission: Annual Census of Staff*, and copies are obtainable from the publicity officer of the Commission, 222 Marylebone-road, London, N.W.1, price 1*s.*, post free.

The statistics are classified under five headings: British Railways; ships and marine; inland waterways; docks, harbours and wharves; and hotels and catering. The basic rates of pay of the 511,562 men employed by British Railways averaged £7 6*s.* 3*d.* a week, but their average weekly earnings amounted to £9 8*s.* 2*d.* The highest-paid men employees were the salaried staffs, of whom there were 77,133. Their average basic rate was £9 5*s.* 0*d.* a week and their average earnings £10 4*s.* 8*d.* a week.

The most numerous section of men employees was the conciliation staff, who numbered 321,355. Their average basic rate of pay was £7 2*s.* 6*d.* a week and their average earnings £9 2*s.* 10*d.* a week. Men employed in the workshop grades numbered 113,074. Their average rate of pay was the lowest of the three categories, being only £6 10*s.* 5*d.* a week, but their average earnings amounted to £9 12*s.* 1*d.* a week.

There were 33,118 women employed by British Railways during the week in question. Their average rate of pay was £5 9*s.* 9*d.* a week and their average earnings £5 15*s.* 7*d.* a week.

LONDON DOCK STRIKE SPREADS

There has been a further worsening of the dock strike situation and on Tuesday nearly half of the country's 76,000 dock workers were on strike. At Birkenhead, all the port's 2,000 dockers were then idle, but not more than 7,000 of the 15,500 dockers at Liverpool had joined in the dispute.

Mr. Arthur Deakin, the general secretary of the Transport and General Workers' Union, has on several occasions roundly condemned the strike, which began at London docks on October 4, when the 7,000 members of the National Amalgamated Stevedores and Dockers ceased work, with the approval of their union, as a protest against the compulsory nature of overtime in the dock industry.

On Saturday, it was announced that Sir Walter Monckton, the Minister of Labour and National Service, had set up a court of inquiry to investigate the causes and progress of the dispute. The three members of the court are Sir Raymond Evershed, Master of the Rolls; Sir Godfrey Mitchell, chairman of George Wimpey and Company, Limited; and Mr. J. Crawford, President of the National Union of Boot and Shoe Operatives.

The court held their first formal meeting, in public, at the Seymour Hall, London, on Wednesday. Their report is expected to be ready in about a fortnight.

TALLY CLERKS' ATTITUDE

Last Friday, the executive committee of the Watermen, Lightermen, Tugmen and Bargemen's Union decided that the 4,500 members of that union at London docks would join in the strike as from Sunday, in support of the N.A.S.D. The committee subsequently announced that all their members had ceased work.

Special interest attaches to the attitude of the London tally clerks, one of the groups of keymen in the industry. At a mass meeting at Canning Town last Friday, the clerks gave unanimous approval to two resolutions, one of which stated that, although realising the need for the working of overtime, owing to the nature of the industry, they would in no circumstances accept the principle of compulsory overtime. The other resolution declared that the men considered that an inquiry should be held into the alleged failure of their union's leaders to pay heed to the demands of the members generally.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Presidential Address by Bryan Donkin. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Oct. 26, 6.30 p.m.

British Institution of Radio Engineers

LONDON
Presidential Address by Rear-Admiral (L) Sir Philip Clarke, K.B.E., at 7 p.m. Annual General Meeting, for members of the Institution, at 6 p.m. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Oct. 27, 6 p.m.

Chemical Society

BRISTOL
"Recent Advances in Fluorine Chemistry," by Professor H. J. Emeléus. Bristol Branch. Department of Chemistry, The University, Bristol. Thurs., Oct. 28, 7 p.m.
DURHAM
"Chemical Microscopy," by Dr. N. H. Hartshorne. Newcastle and Durham Branch. Science Laboratories, Durham. Mon., Oct. 25, 5.15 p.m.
LEEDS
"Polyester Fibres and Terylene," by Dr. Rowland Hill. Leeds Branch. The University, Leeds. Tues., Oct. 26, 6.30 p.m.
LIVERPOOL
"Chemisorption and Catalysis," by Dr. F. C. Tompkins. Liverpool Branch. The University, Liverpool. Thurs., Oct. 28, 5 p.m.
NEWCASTLE-UPON-TYNE
"Some Physico-Chemical Studies on π-Electron Compounds," by Professor A. R. J. P. Ubbelohde. Newcastle and Durham Branch. Chemistry Building, King's College, Newcastle-upon-Tyne. Fri., Oct. 29, 5.30 p.m.

Incorporated Plant Engineers

BIRMINGHAM
Film Evening. Birmingham Branch. Imperial Hotel, Birmingham. Fri., Oct. 29, 7.30 p.m.
LEEDS
Discussion on "Heatless Repair of Broken Castings." West and East Yorkshire Branch. The University, Leeds. Tues., Oct. 26, 7.30 p.m.
SHEFFIELD
"Boiler Feedwater Treatment for Industrial Problems," by C. J. Carter. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Oct. 28, 7.30 p.m.

Institute of British Foundrymen

BIRMINGHAM
"Production of Heavy Steel Castings," by S. Taylor, with film. Birmingham Branch. James Watt Memorial Institute, Great Charles-street, Birmingham 3. Wed., Oct. 27, 7.15 p.m.

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SYMPOSIUM ON POWDER METALLURGY

Papers for December Meeting

A symposium on "Powder Metallurgy," organised by the Iron and Steel Institute in association with the Institute of Metals, will take place in the Hoare Memorial Hall, Church House, London, S.W.1, on Wednesday and Thursday, December 1 and 2. The morning sessions will both be held from 9.30 a.m. until 12.45 p.m. The afternoon session will open at 2.15 p.m. and close at 5.30 p.m. on the first day and will last from 2 until 5 p.m. on the second day. On the first morning the proceedings will be opened by the Hon. R. G. Lyttelton, President of the Iron and Steel Institute, supported by Dr. S. F. Dorey, C.B.E., F.R.S., President of the Institute of Metals. Thereafter each session will be in charge of a member of the organising committee.

The fifty papers contributed to the symposium have been divided into four groups, each to be presented by a *rapporteur*. The first group deals with the "Manufacture, Properties and Testing of Powders," and the *rapporteur* is Dr. A. L. Northcott. Group II is concerned with the "Principles and Control of Compacting and Sintering," and the *rapporteur* is Dr. A. Blainey. Group III relates to the "Manufacture and Properties of Structural Engineering Components," and the *rapporteur* is Dr. P. R. Marshall. The *rapporteur* for Group IV, which covers "Powder Metallurgy of High Melting Point Materials," is Mr. B. E. Berry.

The symposium is open to all interested in the subject and tickets of admission will not be required. Reply forms for the use of those wishing to attend, however, and to obtain copies of the proceedings may be obtained on application to the secretary of the Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1.

A small exhibition of powder-metallurgy components will be staged in committee room No. 6 in Church House during the days of the symposium. It will be open from 9.30 a.m. on both days and will close at 7.45 p.m. on the first day and at 5 p.m. on the second day.

Institute of Fuel

LIVERPOOL
"Shell Boilers," by A. D. C. Gunn. Merseyside Sub-Section. Joint Meeting with the North-Western Division of the National Smoke Abatement Society. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., Oct. 28, 7 p.m.
MANCHESTER
"An Account of American Fuel Research and the Work of the New Fuel Efficiency Service," by Dr. W. A. Macfarlane. Joint Meeting with the National Smoke Abatement Society. Engineers' Club, Albert-square, Manchester. Wed., Oct. 27, 2.15 p.m. (Luncheon, 1 p.m.)

Institute of Marine Engineers

LIVERPOOL
"Marine Diesel Engines," by A. G. Arnold. Merseyside and North-Western Section. Junior Lecture. Old Swan Technical College, Liverpool. Fri., Oct. 29, 7 p.m.

Institute of Petroleum

MANCHESTER
"Testing Lubricants for the Prevention or Promotion of Wear," by T. B. Lane. Northern Branch. Engineers' Club, Albert-square, Manchester 2. Fri., Oct. 29, 6.45 p.m.

Institute of Road Transport Engineers

DURHAM
"Protective Finishes for Road Vehicles," by W. T. Watson. North-East England Group. Royal County Hotel, Durham. Tues., Oct. 26, 7 p.m.

Institution of Civil Engineers

LONDON
"The Queen Elizabeth II Dock," by D. C. Milne. Maritime Division. Tues., Oct. 26, 5.30 p.m.
BIRMINGHAM
"Site Investigation for Foundations," by A. Mackey. Midlands Association. Graduates' and Students' Meeting. Civic Centre, Birmingham. Fri., Oct. 29, 6 p.m.
SCUNTHORPE
"The Design and Construction of the Handling and Treatment System for Liquid Radio-Active Wastes," by W. L. Wilson; and "Operational Experiences with a Handling and Treatment System for Liquid Radio-Active Wastes," by R. H. Burns. Yorkshire Association. Blue Bell Hotel, Scunthorpe. Fri., Oct. 29, 6.30 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Whether Compatibility is Necessary for a Colour Television System in Great Britain," opened by E. P. Wethey. Radio Section. Mon., Oct. 25, 5.30 p.m.
Chairman's Address, by J. D. Peattie, Supply Section. Wed., Oct. 27, 5.30 p.m.
ARBORFIELD
Chairman's Address on "The History of the Institution," by M. C. Cubitt. London Students' Section. R.E.M.E. Training Centre, Hazebrouck Barracks, Arborfield, Berkshire. Tues., Oct. 26, 7 p.m.
CARLISLE
"Earthing," by P. W. Cave. North-Eastern Centre. North-Western Electricity Board's Recreation Club, Carlisle. Tues., Oct. 26, 7 p.m.
CHESTER
"Service Experience of the Effect of Corrosion on Steel-Cored-Aluminium Overhead-Line Conductors," by Dr. J. S. Forrest and J. M. Ward. Mersey and North Wales Centre. Town Hall, Chester. Mon., Oct. 25, 6.30 p.m.
MALVERN
"The Experimental Synthesis of Speech," by W. Lawrence. South Midland Centre. Winter Gardens Restaurant, Great Malvern. Tues., Oct. 26, 7.15 p.m.
NEWCASTLE-UPON-TYNE
"Aluminium-Sheathed Cables," by P. M. Hollingsworth and P. A. Raine. North-Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Oct. 25, 6.15 p.m.
NOTTINGHAM
"The Combined Magnetisation of Irons," by Dr. J. E. Parton. East Midland Centre. Gas Board's Demonstration Theatre, Nottingham. Tues., Oct. 26, 6.30 p.m.
WEYMOUTH
"Loudspeaker System: Recent Trends in Loudspeaker Design," by Major A. E. Falkus. Southern Centre. Technical College, Weymouth. Fri., Oct. 29, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Units of Measurement of Length, Mass and Force Employed in the Teaching of Applied Mechanics and General Mechanical Engineering Subjects." Education Group. Wed., Oct. 27, 6.45 p.m.
Parsons Memorial Lecture on "Factors Influencing the Continuing Development of the Steam Turbine," by F. Dollin. Fri., Oct. 29, 5.30 p.m.
CARDIFF
"High-Temperature Cooling of Open-Hearth Furnaces by Means of Steam Producing Elements," by P. M. Moreton; and "The Efficient Production and Utilisation of Steam in Steelworks," by F. J. Feltoe. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Oct. 26, 6 p.m.
CHELTENHAM
"An Introduction to Wind Tunnels and Their Applications," by A. Rimmer. Western Graduates' Section. St. Mary's College, Cheltenham. Thurs., Oct. 28, 7.30 p.m.

Institution of Production Engineers

CARDIFF
"High-Speed Presswork," by J. A. Grainger. South Wales and Monmouthshire Section. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Oct. 28, 7 p.m.
DUNDEE
"The Motion-Study Aspect of Work Study," by Miss Anne Shaw. Dundee Section. School of Economics, Dundee. Wed., Oct. 27, 7.30 p.m.
LINCOLN
"How the Production Engineer Can Be Helped by the Metallurgist," by Dr. J. D. Jevons. Lincoln Section. Ruston Club, Unity-square, Lincoln. Sat., Oct. 30, 7.30 p.m.
LUTON
"High Permeability Steel Castings for the Electrical Industry," by J. F. Hinsley. Luton Section. Town Hall, Luton. Tues., Oct. 26, 7.15 p.m.
MIDDLESBROUGH
"Machines and Men," by Professor Aubrey F. Burstall. Tees-Side Section. The Cleveland Scientific and Technical Institution, Middlesbrough. Wed., Oct. 27, 7 p.m.
SHEFFIELD
"Shell Moulding," by D. N. Buttrey. Sheffield Graduate Section. Royal Victoria Station Hotel, Sheffield. Mon., Oct. 25, 6.30 p.m.
SHREWSBURY
"Colour as an Aid to Production," by Miss A. Raine. Shrewsbury Section. Oakengates Technical College, Oakengates, Shrewsbury. Wed., Oct. 27, 7.30 p.m.
WORCESTER
Film Evening. Worcester Section. Cadena Café, Worcester. Wed., Oct. 27, 7.30 p.m.

Institution of the Rubber Industry

MANCHESTER
"Stores Control of Raw Materials Used in the Insulated Wire and Cable Industry," by C. W. Kelsey. Manchester Branch. Engineers' Club, Albert-square, Manchester 2. Mon., Oct., 25, 6.15 p.m.

Institution of Sanitary Engineers

LONDON
"Some Aspects of Administrative and Establishment Work in the Engineer's Department of a Large Municipal Authority," by J. F. Lyne. Caxton Hall, Victoria-street, S.W.1. Wed., Oct. 27, 6 p.m. (Alteration of date.)

Junior Institution of Engineers

LONDON
"Some Notes on the Static Compressive Strength of Wool Felt, with Reference to the Isolation of Shock," and "Some Notes on the Dynamic Characteristics of Wool Felt," by R. J. Herbert. Fri., Oct. 29, 7 p.m.

Manchester Association of Engineers

MANCHESTER
"Testing Lubricants for the Prevention or Promotion of Wear," by T. B. Lane. Engineers' Club, Albert-square, Manchester, 2. Fri., Oct. 29, 6.45 p.m.

Manchester Metallurgical Society

MANCHESTER
"Metallurgical Problems of Atomic Energy," by Dr. H. M. Finniston. Central Library, Manchester. Wed., Oct. 27, 6.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Ship Structural Members. Part VI," by J. McCallum. Mining Institute, Newcastle-upon-Tyne. Fri., Oct. 29, 6.15 p.m.

Royal Statistical Society

LONDON
"Statistics and the Accountant," by W. F. Harris. London Industrial Applications Group. Caxton Hall, Victoria-street, S.W.1. Fri., Oct. 29, 7 p.m.
SHEFFIELD
"Analysis and Use of Industrial Data," by Miss J. Keen. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., Oct. 28, 6.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Modern Precision Weighing," by Dr. G. I. Hodsman. Methods of Analysis Group. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield 3. Tues., Oct. 26, 7 p.m.

Society of Instrument Technology

LONDON
Presidential Address; and "Power Plant Level Control: British and American Methods," by W. R. Kennedy. Joint Meeting of Main Society and Control Section. Manson House, 26 Portland-place, W.1. Tues., Oct. 26, 7 p.m.

Women's Engineering Society

LONDON
"The Metal-Spraying Process," by J. A. Shepherd. London Branch. Mon., Oct. 25, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Sanitary Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 20 Booth-street, Manchester, 2. (Central 2796.)
Manchester Metallurgical Society, The Kennedy Press, Ltd., 31 King-street West, Manchester, 3.
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield, 7. (Sheffield 53674.)
Society of Instrument Technology, 55 Tudor-gardens, London, W.3.
Women's Engineering Society, 35 Grosvenor-place, London, S.W.1. (SLOane 0401.)